MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The Engineering Profession

Engineering work has become an increasingly important factor in the progress of civilization and in the welfare of the community. The engineering profession is held responsible for the planning, construction and operation of such work, and is entitled to the position and authority which will enable it to discharge this responsibility and to render effective service to humanity.

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MAY 1923

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DEPARTMENTAL

ADVERTISING

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Contributors and Contributions

The Cross-Flow Impulse Turbine

FORREST NAGLER

The advancement of civilization has followed closely on the perfection of prime movers. The first prime mover was a water wheel of the impulse type. Forrest Nagler's paper in this issue describes a new type of water wheel for high heads which departs radically in principle from present practice. Mr. Nagler received his B.S. in mechanical engineering from the University of Michigan in 1906 and since his graduation has been with the Allis-Chalmers Manufacturing Co. In his work on axial-flow hydraulic-turbine runners he has developed a suction type of high-speed, low-head runner which holds several world records for capacity. Life Membership in the A.S.M.E. was awarded him in 1919 for his paper describing this work.

Lignite Char

O. P. Hood, chief mechanical engineer of the U. S. Bureau of Mines and in charge of the Bureau's fuel investigations, discusses the handicaps and possibilities of lignite char as fuel. Before assuming his present position in 1911 Mr. Hood spent twelve years in the engineering department at Kansas State Agricultural College, and from 1898 to 1911 he was professor of mechanical and electrical engineering at the Michigan College of Mines. He holds degrees from Rose Polytechnic Institute.

Aluminum Bronze as an Engineering Material

W. M. Corse, chairman of the Division of Research Extension of the National Research Council, was graduated from the Massachusetts Institute of Technology with the degree of B.S. in 1899. He went to work immediately as a chemist and has specialized in the manufacture of non-ferrous alloys, principally brass and bronze. He has worked for the Detroit White Lead Works, the Detroit Lubricator Co., Titanium Bronze Co., the Ohio Brass Co., and the Monel Metals Products Company. At present he is consulting engineer for the International Nickel Co. and the Buffalo Bronze Die Case Corporation.

High-Temperature and High-Pressure Steam Lines

A paper giving available data and formulas on radiation and friction losses in pipe lines is presented by B. N. Broido, consulting engineer with the Superheater Co. Mr. Broido was born in Russia and educated in Germany. His early work on superheaters was done in Germany with the Seiffert Co. and the Egestorf Machine Manufacturing Co. In 1914 he came to this country where he took post-graduate work in New York City. Before assuming his present position Mr. Broido did designing work for the Roessler & Hasslacher Chemical Co. and the Philadelphia and Reading Railway Co. He has filed over forty patent applications.

Refinery and Rolling Mill for Monel Metal

Economic problems involved in selecting a site for a mill for rolling monel metal and facts leading to their solution are given by W. L. Wotherspoon in a paper describing such a mill at Huntington, West Va. Mr. Wotherspoon is of English birth and received his training at large engineering works in England and South Africa, where he was a member of the consulting staff of the Central Mining and Investment Corporation of Johannesburg. In 1912 he came to New York where he has been executive engineer in charge of engineering and construction work for the International Nickel Co.

Management Engineering in Paper Industry

R. B. Wolf is president of The R. B. Wolf Co., of New York City, an organization specializing in the design, construction, and operation of pulp and paper mills. He was graduated from Delaware College in 1896 as an electrical engineer, but two months after his graduation he determined to enter the paper business. Beginning as a "workman" he has worked in practically every department of a paper mill. He resigned his position as manager of the Spanish River Pulp and Paper Mills during the war to become staff assistant to vice-president Piez of the Emergency Fleet Corporation.

The Oil Venturi Meter

The measurement of the flow of viscous fluids is discussed in this issue by E. S. Smith, Jr., of the California National Supply Co. of Los Angeles. Mr. Smith, who is a graduate of the University of California, class of 1919, has done special research work at the University, and for two years was an engineer testing venturi and orifice meters at the Standard Oil Company's refinery at Richmond.

Boiler-Furnace Design

Edwin B. Ricketts, assistant to the chief operating engineer of the New York Edison Co., contributes a paper on boiler-furnace design to this issue. Mr. Ricketts received the degree of B.S. from Millsaps College in Mississippi in 1901. He has been employed by various iron and steel works throughout the country, and previous to his last connection with the N. Y. Edison Company he designed and built a glass-manufacturing plant for the United States Glass Co. of Pittsburgh.

A.S.M.E. Spring Meeting

Montreal, May 28-31

The interesting technical program and many points of excursion interest bid fair to make the coming Spring Meeting the most popular of any recent Spring Meetings of the Society.

There will be sessions on Hydroelectric Power, Management, Port Development, Railroads, Textiles, Fuels and Machine-Shop Practice.

Complete particulars of the final program are given in the April 22 issue of the A.S.M.E. News.

MECHANICAL ENGINEERING

Volume 45 May, 1923 No. 5

The Cross-Flow Impulse Turbine

Particulars Regarding a New Type of Water Wheel Designed for Use with High Heads

By FORREST NAGLER,[1] MILWAUKEE, WIS.

THE ORIGIN of the first prime mover is lost in antiquity, but we are able to state with practical certainty that it was an impulse-type water wheel; more specifically, that it was of the impact type, a current wheel with flat paddles, but an impulse wheel nevertheless. Written descriptions of these wheels date back nearly 2000 years, and current wheels, modified possibly to a slight extent in the direction of breast wheels, are probably several times that old.

It is with the history of this type of prime mover, its modification to date, its present state of development and possible improvement that this paper is to deal.

The term "impulse" is commonly used with those wheels in which water is applied to the rotating element in a free jet with all its energy in the form of velocity. It will be so used here although the term is somewhat of a misnomer as modern impulse wheels develop power as much by reaction as they do by impulse or impact. The term "impulse" or perhaps better, "impact" might have been accurately used to designate the original current wheels and some of the pioneer forms, such as the hurdy-gurdy wheel, where the water was received on flat surfaces and no attempt was made to utilize the reaction of the water leaving the wheel. The modern wheel, however, receives the water without shock, completely avoiding what might be termed impact, and turns it by a smooth path into a relative direction substantially contrary to that of the motion of the wheel. The essential distinction between the hydraulics of the so-called impulse wheel and the reaction type is found in the fact that in the former the entire energy of the water received by the wheel is in the form of velocity.

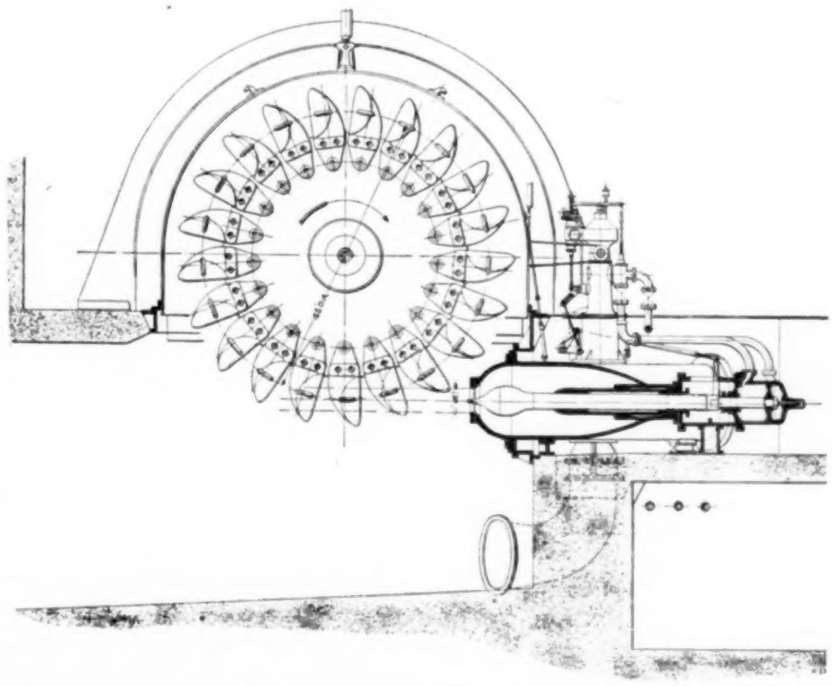

Fig. 1 One of the Two Wheels of the Largest Impulse-Wheel Unit Yet Installed

(One of two units built in 1919 for the Caribou plant of the Great Western Power Co., California. Rated capacity of unit, 30,000 hp.; effective head, 1008 ft.; speed, 171 r.p.m.)

As this paper has to deal primarily with a modification of a single type of wheel or turbine the nomenclature of which is fairly well established, the term "impulse" will be adhered to as covering the general and specialized forms known variously as Pelton, tangential, Girard, Schwankrug, pressureless, and impulse or action types as contrasted to Francis, Jonval, Fourneyron, pressure, and reaction. It is with this thought of conforming to accepted practice that the term "impulse" is employed.

Historical

Prior to recorded history we may infer that mankind required a matter of centuries to produce the flat-blade impulse wheel. We know that this type persisted with little or no change, up to about the sixteenth century A.D., that is, about two thousand years.

It required three hundred years more to definitely get beyond the flat-blade stage, realization of its disadvantages (only 50 per cent maximum theoretical efficiency) not materially affecting practice up to about 1850, although the faults of the flat blade were recognized 100 years previously. Some samples of the impact type of wheel survived in our own country up to the latter part of the nineteenth century, these being represented typically by the hurdy-gurdy wheel of the California mining days. Actual installations of this crude wooden wheel with its flat impact surfaces were made as late as 1880, but it gave way to the impulse wheel in approximately its present form, Fig. 6 (*a*), during the period of 1870 to 1880.

As late as 1883 and again in 1890–1891 comprehensive tests made on impulse wheels included tests on designs of flat-vane wheels. Bulletin No. 1 of the University of California (June, 1883) is probably the impulse-wheel classic for all time. It sets forth clearly the reaction principle for all types, illustrates and analyzes arrangements of radial- and axial-flow circular-jet wheels, impact wheels with flat surfaces, single-lobe tangential wheels and true splitter types. The mathematical analysis is exceptionally comprehensive without losing simplicity. Full appreciation of inherent disadvantages such as "backed" water loss was shown. Tests on impact wheels (40 per cent best efficiency) and Pelton wheels (82 per cent best efficiency) are given. Incidentally, this latter efficiency has not since been materially improved upon, considering the small jet size ($^3/_8$ in.) and low head (50 ft.).

Tests at the University of Michigan by Profs. M. E. Cooley, C. E. DePuy and L. J. Hill in 1890–91 similarly included tests on both impact and impulse wheels of commercial forms and with

[1] Hydraulic Engineer, Allis-Chalmers Mfg. Company, Mem. A.S.M.E.

Presented at a meeting of the Milwaukee Section, Feb. 20, 1923. Also presented at the Pacific Coast Regional Meeting of The American Society of Mechanical Engineers, Los Angeles, Cal., April 16 to 18, 1923. Abridged.

modifications to improve the efficiencies of both. A maximum of 37 per cent with flat blades and 82.75 per cent efficiency with Pelton buckets were obtained, the nozzle being $^3/_8$ in. in diameter and the head 92.4 ft. Analyzing the separate losses the authors concluded that the bucket efficiency approximated 90 per cent, that the nozzle efficiency could be brought to 99 per cent, but that windage and friction losses could hardly be reduced below $3^1/_2$ per cent.

In the United States occasional patent references are available back to 1850, but in none of them is there a clear setting forth of

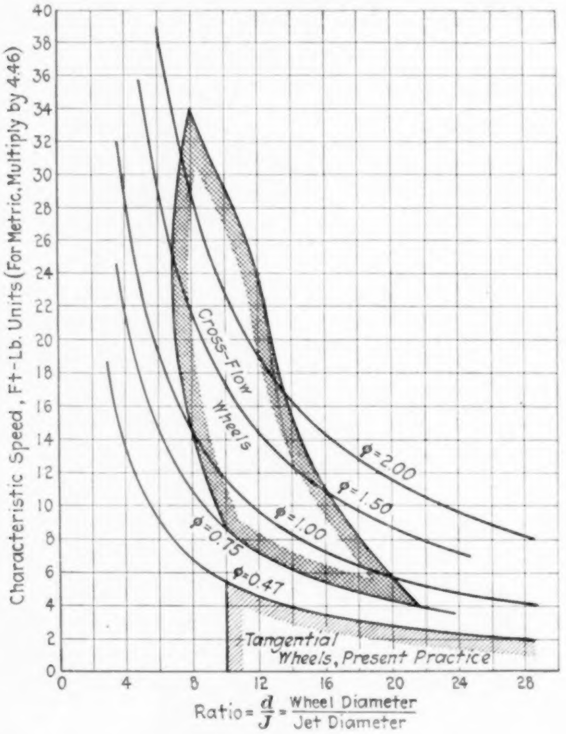

Fig. 2 Curves Showing Relation Between Characteristic Speeds of Impulse Wheels and Their Proportions as Evidenced by the Ratio d/J

(The plottings for the various peripheral coefficients indicate the increases possible with larger coefficients than are used at present. The lower shaded area indicates the approximate limits of proportions and characteristic speeds of tangential impulse wheels, and the upper area roughly the field available for development by the cross-flow wheel. The increase in characteristic speeds that is possible is quite strikingly shown.)

the reaction principle as applied to impulse wheels nor a construcion suitable for applying the principles until subsequent to that date. The earliest written account is that of Atkins, who applied for patents in 1853, although issue was delayed until 1875. Apparently Atkins fully appreciated the hydraulic principles involved.

It remained, however, for the mining industry of California to produce the predecessors of the type accepted universally at present. This was perhaps inevitable as they, to probably to a greater extent than any other group of men in the world, were in daily contact with large-sized jets of water under high pressure. The first application of these jets was for the purpose of hydraulic mining, but the developing of power followed immediately. The wheels first used were known generally as the hurdy-gurdy wheels and they dominated the period from 1850 to 1870.

The development work of the period 1870–1880 is dominated by the names of Knight, Moore, Hesse, and Pelton. The origin of the present type of tangential wheel, characterized by its cup-shaped bucket for securing full reaction and by its splitter for avoiding impact losses, lies with some or all of this group of men, but Pelton undoubtedly did most to develop and commercialize this form and to him belongs the credit for first increasing the efficiency to approximately where it stands today. Later modifications were made to improve the efficiency, to avoid erosion or secure some better mechanical standard, but the inherent characteristics have so far remained unchanged.

A most interesting historical account[1] and analysis of Pelton's work is contained in the report of a Committee appointed by the Franklin Institute. This covered the various works, both European and American, leading up to Pelton's, disposed of contending claims and finally made unqualified award on the basis of simplicity, economy of maintenance, adaptability to high heads, transportability, newness, correctness of principle, and commercial importance, but above all from the standpoint of efficiency. An appended test made at the U.S. Naval Academy in 1895 by Lieutenant F. J. Haeseler, U.S.N., and Ensign W. H. G. Bullard, U.S.N., shows a maximum efficiency of 86.56 per cent with a $^3/_4$-in. jet developing only 7.756 hp., volumetric measurement of water being used. This is the type that has remained unchanged to date.

[1] *Journal of the Franklin Institute*, September, 1895.

European practice starting along a divergent line during the incubation period (1850–1880) of the American designs developed the Girard axial-flow and Schwankrug radial-flow impulse wheels for high head.

Any working mechanism exposed to fluid in motion should desirably have the smallest possible hydraulic radius, that is, the least surface in contact with the water, to minimize losses and variations in velocity. For any given area the circle is the most advantageous shape as no figure has a greater area for a given periphery.

The accident of circular jets used in our western mining work was responsible for a feature of design that was very instrumental in causing the American design of impulse wheel to supersede all others. This circular-jet nozzle, later of the needle type developed by Mr. Doble, obviated pitting trouble and low nozzle efficiency (frequently as low as 85 per cent) encountered in the various forms of partial annular nozzles, square nozzles and tongue nozzles that characterized European design and were features of practically all Girard and Schwankrug wheels. Other than circular jets may work out advantageously, but so far all types of impulse wheels using them under high heads have failed or have been superseded commercially.

All impulse wheels have gradually resolved themselves into the specialized type known variously as the Pelton wheel, the tangential wheel, or more generally the impulse wheel. These have been

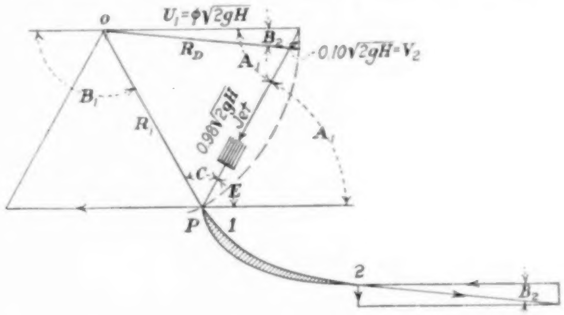

Fig. 3 Fundamental Diagram of the Impulse Wheel

(Diagram is laid out for the axial cross-flow type of wheel, but represents an average of all types, whether of radial-inward, radial-outward, conical, or axial arrangement.)

highly improved, are very simple, efficient, and reliable, and gradually all other forms of pressureless wheels have given way to them. The last to go was the Girard impulse wheel or Girard turbine as it is variously known. On account of its relatively large nozzle area it had a high characteristic speed and filled a gap not covered by either Pelton or Francis wheels except disadvantageously by the multiple-jet types of the former.

Characteristics of the Impulse Wheel

Practically all writers of hydraulic textbooks agree in their treatment of the impulse wheel that it is known by the following characteristics, the first three applying to impulse wheels in general, and the fourth identifying the present dominant type.

1 A free jet operating under the full spouting velocity due to the operating head
2 Substantially tangential application of the jet to the wheel, that is, with the major component of jet velocity along a tangent
3 A bucket velocity practically 50 per cent of the jet velocity
4 Splitter-type buckets concave on the working surfaces.

According to definition, characteristic No. 1 is inherent with

all impulse wheels. Nos. 2, 3, and 4 dominate the impulse-wheel field at present and have done so with almost no interference for thirty years, within which period practically all the development of modern water-power machinery has taken place. During the first half of this period these characteristics covered commercial requirements which demanded the slowest-speed wheel that could be made under high heads. While certain conditions, notably high heads, still demand tangential wheels for about 15 or 20 years, the requirements of commercial practice have frequently exceeded limitations imposed by characteristics Nos. 2, 3, and 4, and to meet these new conditions the new form of wheel proposed by the author has departed from these three characteristics in a decided and radical manner.

Contrary to the general impression, the modern impulse wheel is the slowest-speed type of turbine known, although it utilizes the highest water velocities. This low-speed type has found an extensive field of usefulness by reason of its mechanical simplicity and the relatively small surface exposed to high water velocities. Its mechanical simplicity permitted the original development of this type without going beyond the capacity of carpenter's and blacksmith's tools. Its low speed was essential in connection with the small capacities and high heads to which it was adapted, as it permitted revolutions per minute sufficiently low to readily permit of direct connection with alternators of reasonable speed. Its arrangement permits elimination of clearances and packing, which involve careful design and fine machine work and are a continual source of trouble under high heads. The small

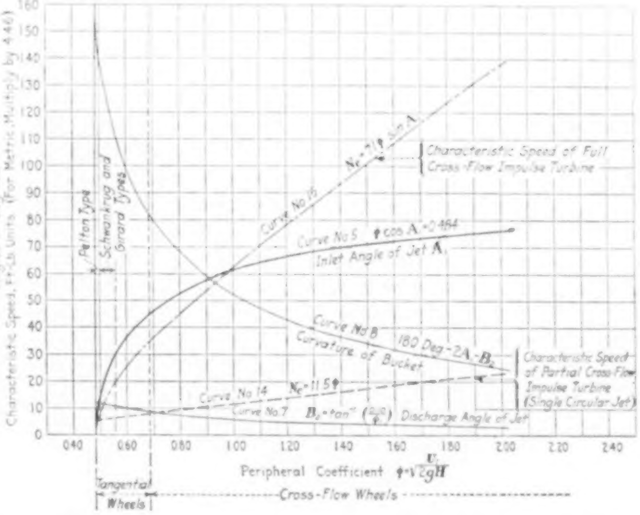

Fig. 4 Diagram of the Entire Field of Impulse Wheels, Showing the General Characteristics of Modern Tangential Impulse Wheels of the Superseded Historical Types and of the Proposed New Cross-Flow Type

(Assumptions: Discharge loss = 0.10 $\sqrt{2gH}$; jet velocity = 0.98 $\sqrt{2gH}$; overall efficiency = 80 per cent; d/J = 10.)

amount of surface exposed to water flow and the ease with which such surfaces may be inspected and renewed overcame one of the greatest problems in high-head turbine design.

It is probable that the intimate association of the low peripheral coefficient of 50 per cent with impulse-wheel design results from the fact that practically without exception authors of hydraulic treatises and writers of textbooks on the subject of hydraulic-turbine design confine themselves almost solely to this basis.

It is to this that the author takes exception, particularly since this 50 per cent basis is usually presented as a very fundamental consideration of all impulse-wheel design, whereas it really should be presented as an extreme used to permit of securing the lowest possible bucket speed. A single glance at the complicated forms of the most noteworthy impulse-wheel installation of the last few years should be all that is needed to indicate to the unbiased engineer whose ideas have not already been prematurely and positively fixed along a certain line, that the desirability of low speed in the buckets of these units has long since passed. The unit of Fig. 1 illustrates this point, as do also all of the record capacity units above 5000 hp. or since 1904.

So far as water velocity is concerned, the impulse type of wheel should have the highest speed of any type of turbine, except those which may be classed within the so-called "suction" field. The water velocity in the usual reaction wheel (Francis) seldom exceeds 50 to 75 per cent of the spouting velocity, or the same percentage of that which holds in all impulse practice. The main reason for the low characteristic speed of impulse wheels is found in the fact that the whole periphery of the Francis is utilized for developing powers, whereas the usual impulse wheel comes under the classi-

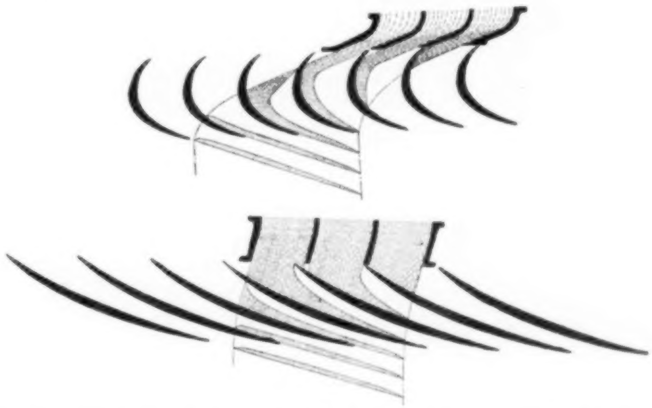

Fig. 5 Diagrams Illustrating the Relatively Smaller Portion of the Periphery of a Wheel Utilized by a Given Jet of the Cross-Flow Type as Contrasted With That of the More Nearly Tangential Flow. The Possibility of Utilizing a Larger Number of Jets Without Interference is Evidenced

fication of partial turbine. The result is that in comparing on the basis of a certain hp. the diameter of the impulse type becomes so large that its r.p.m. is unduly reduced. This is further emphasized by the fact that the reaction wheel usually runs with a coefficient of rim velocity in the neighborhood of 60 to 90 per cent as contrasted to the 50 per cent for the present impulse type.

Speeds of tangential impulse wheels cannot be increased by reducing their diameter beyond a certain limit illustrated in the lower curve of Fig. 2, because the bucket turns so abruptly out of the working path of the jet. The relationship between the characteristic speed of the tangential impulse wheel and its ratio of wheel to jet diameter illustrate the approximate limitations of commercial practice. Exceeding the ratios indicated simply means that there will be what is called "racing water," with its inherent loss of efficiency.

Unit capacities have so grown that for a considerable period, possibly for the last 15 or 20 years, strenuous efforts have been made to increase specific speeds of impulse units. As is usual in such cases, human inertia has been such that the new need was not recognized, the result being that the art of impulse-wheel design went through the same evolution as did that of reaction-type turbines, i.e., multiplicity of runners, nozzles, etc., without attacking the fundamental element of relative bucket velocity or direction of jets on the wheel to avoid interference. The orthodox 50 per cent velocity of bucket and tangential application of jet with its large consumption of wheel periphery were and still are the dominant factors of the impulse units of even recent manufacture and of all engineering textbooks on the subject.

Experimental Work of the Author

During the years 1913 to 1918 the author was experimenting almost continually with flat-angle runners of the axial-flow type. This work resulted in the development of the high-speed suction type of propeller runner since applied extensively to low heads and led to an appreciation of the characteristics necessary to high speed in any vane moving in a fluid. In his paper describing this work before the A.S.M.E. in December, 1919, the following statement was made as covering any water wheel, the ice boat illustration incidentally coming under the classification "impulse" as defined herein.

Neglecting friction and possibly blade thickness, there are no mathematical or hydraulic laws that will prevent doubling or quadrupling any particular characteristic speed by simply flattening the blade angles.

A direct analogy to this is the well-known illustration of relative velocities evidences in the sail of an ice boat.

Continuing this work on high-speed runners with impulse wheels, the author in company with J. F. Roberts experimented with small-angle single-lobe types of buckets with the jet making small angles with the tangent. The purpose was to secure an arrangement whereby more jets might be used on a single wheel without interference and to eliminate the splash losses resulting from water discharged upward and falling back on the wheel in vertical shaft arrangement. The result was difficulty from the "backed" water indicated at B in Fig. 6, which was one of the causes of the low efficiency and pitting that contributed largely to the commercial failure of Girard wheels and other single-flow impulse turbines. In playing jets from an ordinary garden hose on small models of these wheels that were running at a high rate of speed (10,000 to 20,000 r.p.m.) a decided change in their tune was noticed with various positions of the jet. On account of ease in construction one of the wheels happened to have been cast without back curvature of buckets, similar to the propeller-type suction runner. With this wheel the highest pitch or note was developed with the jet directed almost perpendicular to the plane of the wheel. This was so contrary to fundamental impulse practice as indicated by all commercial installations built in recent years and covered in any treatise on hydraulics that it attracted instant attention. Analysis of the condition resulted in a series of diagrams such as Fig. 3, and these worked naturally into the following algebraic analysis.

Let—

$$\text{Jet velocity } V_1 = 0.98\sqrt{2gH}$$

From the right triangle on base OE

$$R_D = \sqrt{U_1^2 + V_2^2}$$

and from the law of cosines

$$R_I = \sqrt{V_1^2 + U_1^2 - 2V_1U_1 \cos A_1}$$

But $R_D = R_I$,

$$\therefore\ U_1^2 + V_2^2 = V_1^2 + U_1^2 - 2V_1U_1 \cos A_1$$

whence

$$\phi^2(2gH) + 0.01(2gH) = 0.96(2gH) + \phi^2(2gH) - 2\,\phi \times 0.98(2gH)\cos A_1$$

and (see curve 5, Fig. 4)

$$\phi \cos A_1 = 0.484 \qquad [1]$$

Note that varying the assumption of $0.10\sqrt{2gH}$ discharge loss has very little effect on the inlet angle.

For the average impulse wheel the bucket inlet angle is practically twice the jet angle, that is (see curve 6, Fig. 4),

$$B_1 = 2A_1$$

Proof:

$R_D = R_I$ since relative velocities are practically constant in an impulse wheel (exactly so in axial flow).

$R_D = OE$ (Fig. 3) very closely since B_2 is always very small. Exact equality could be attained by allowing a slight forward component.

$OE = OP$

$\therefore$ Angle C = Angle A_1

But $A_1 = E$ by construction and $C + E = 2A_1$

$\therefore\ B_1 = 2A_1$

$$B_2 = \tan^{-1}\left(\frac{0.10\sqrt{2gH}}{\phi\sqrt{2gH}}\right) \text{ from right triangle}$$

$$= \tan^{-1}\left(\frac{0.10}{\phi}\right) \qquad [2]$$

$$\text{Bucket curvature} = 180° - B_1 - B_2 = 180° - 2A_1 - B_2$$

$$= 180° - 2\cos^{-1}\left(\frac{0.484}{\phi}\right) - \tan^{-1}\left(\frac{0.10}{\phi}\right) \qquad [3]$$

(See curve 8, Fig. 4.)

With impulse wheels simple relationships may be deduced for comparative purposes as follows, letting J = jet diameter or thickness and d = wheel diameter, both in feet.

The equation for the characteristic speed of the wheel is—

$$N_s = \frac{\text{r.p.m.} \times \sqrt{\text{hp.}}}{H^{5/4}} \qquad [4]$$

and the speed is

$$\text{r.p.m.} = \frac{60\,\phi\sqrt{2gH}}{\pi d} \qquad [5]$$

Assuming 80 per cent efficiency and one circular jet per wheel,

$$\text{hp.} = \frac{\pi J^2}{4} \times \frac{0.98\sqrt{2gH} \times H \times 62.4 \times 0.80}{550} = \frac{J^2H^{3/2}}{1.78}$$

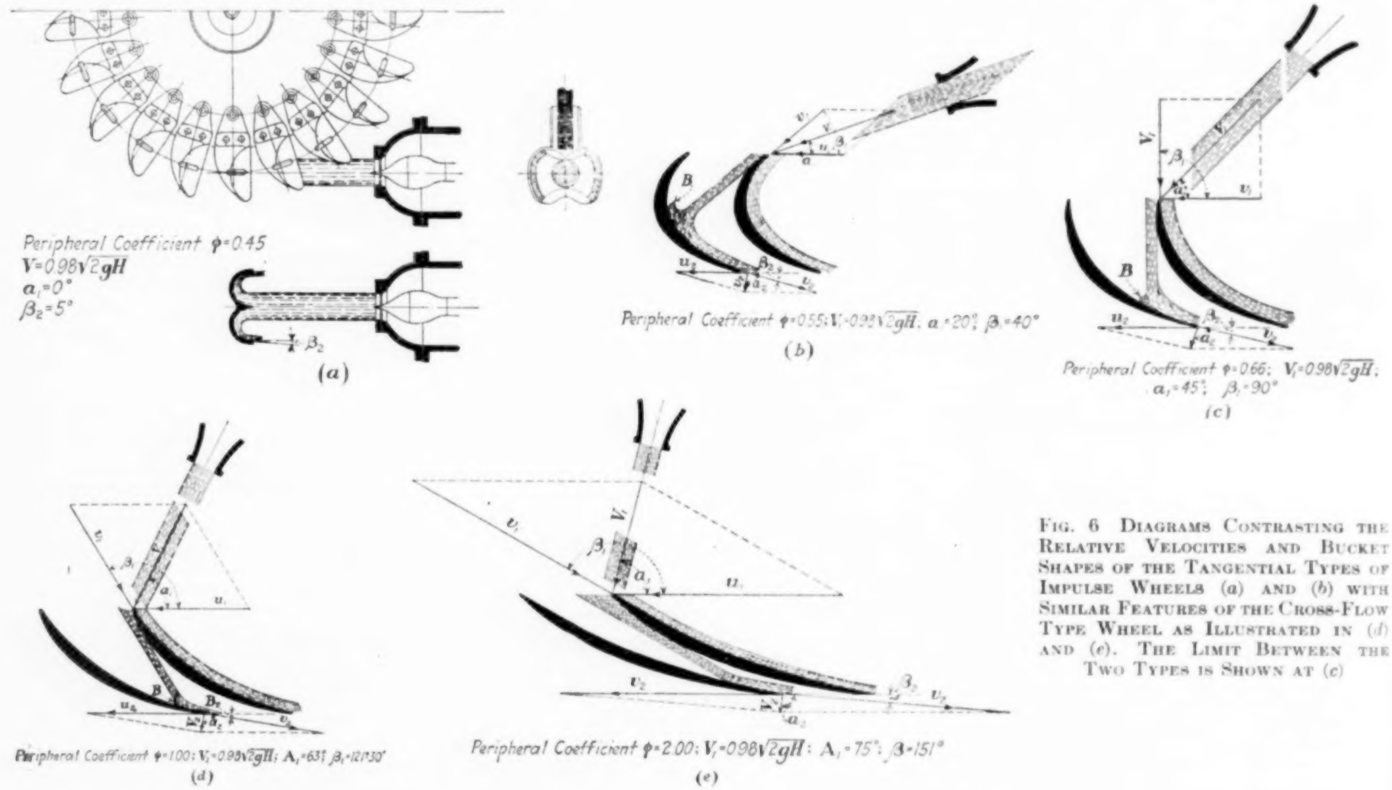

FIG. 6 DIAGRAMS CONTRASTING THE RELATIVE VELOCITIES AND BUCKET SHAPES OF THE TANGENTIAL TYPES OF IMPULSE WHEELS (a) AND (b) WITH SIMILAR FEATURES OF THE CROSS-FLOW TYPE WHEEL AS ILLUSTRATED IN (d) AND (e). THE LIMIT BETWEEN THE TWO TYPES IS SHOWN AT (c)

and

$$\sqrt{\text{hp.}} = \frac{JH^{3/4}}{1.335} \quad\text{.........}\quad [6]$$

Substituting [5] and [6] in [4] gives

$$N_e = \frac{115\ J\phi}{d} \quad\text{.........}\quad [7]$$

Most engineers dealing with the subject are familiar with Equation [7] expressed for tangential wheels as

$$N_e = 55\frac{J}{d} \quad\text{...........}\quad [8]$$

ϕ being taken as equal to 0.48.

Modern tangential impulse wheels preferably have a ratio of wheel diameter to jet diameter of 12 to 14, with 10 as a desirable minimum. Using the latter value for comparative purposes,

$$N_e = 11.5\ \phi \quad\text{.........}\quad [9]$$

for impulse wheels with single circular jets (see curve 14, Fig. 4).

With multiple jets the limit of characteristic speed is reached with a solid annular jet of width J or when the nozzle area is πdJ. In this case, assuming 80 per cent efficiency,

$$\sqrt{\text{hp.}} = \frac{2H^{3/4}\sqrt{dJ}}{1.335}$$

which, substituted with [5] in [4] gives

$$N_e = 225\ \phi\ \sqrt{J/d}$$

neglecting for the moment the jet angle; and for the d/J ratio of 10 assumed above,

$$N_e = 71\ \phi \quad\text{............}\quad [10]$$

Since the full annular area of the nozzle is not effective on account of the inlet angle of the jet expressed in [1], Equation [10] must be altered to read

$$N_e = 71\ \phi\ \sqrt{\sin A_1}$$

(see curve 16, Fig. 4), since the quantity and consequently the hp. vary as the axial or radial component and N_e varies as $\sqrt{\text{hp.}}$

The significant relationship between wheel speed and jet angle is shown perfectly in Equation [1], the graphical showing being curve No. 5 of Fig. 4.

Considering the fact that this relationship is based on the fundamental requirements of an impulse wheel, i.e., low exit loss and constant relative velocity (resulting from no change in pressure) in the bucket itself, the curve may be used for some very broad conclusions. The main one is this:

Speed in impulse-wheel work is a function of the angle the jet makes with a tangent.

If the jet angle is zero as in accepted present practice, the speed, which is a function of ϕ, is the lowest that can be obtained without preventable loss. As the angle of the jet increases to 45 deg. the relative wheel velocity increases from 50 per cent to only 69 per cent of the jet velocity. From this point, however, the most radical increase is effected. For example, from a 69 per cent coefficient at 45 deg. the speed increases to 100 per cent at 61 deg. This feature combined with the obvious departure from the tangential flow of present practice led to the following designation of two classes of impulse wheels accordingly as the major component of the jet velocity is along or normal to the tangent:

Tangential Impulse Wheels—Jets making angle less than 45 deg. with tangent.
Buckets decidedly concave, curvature greater than 90 deg.
Bucket inlet inclined backward.

Cross-Flow Impulse Wheels—Jets making angle greater than 45 deg. with tangent.
Buckets flattened, curvature less than 90 deg.
Bucket inlet inclined forward.

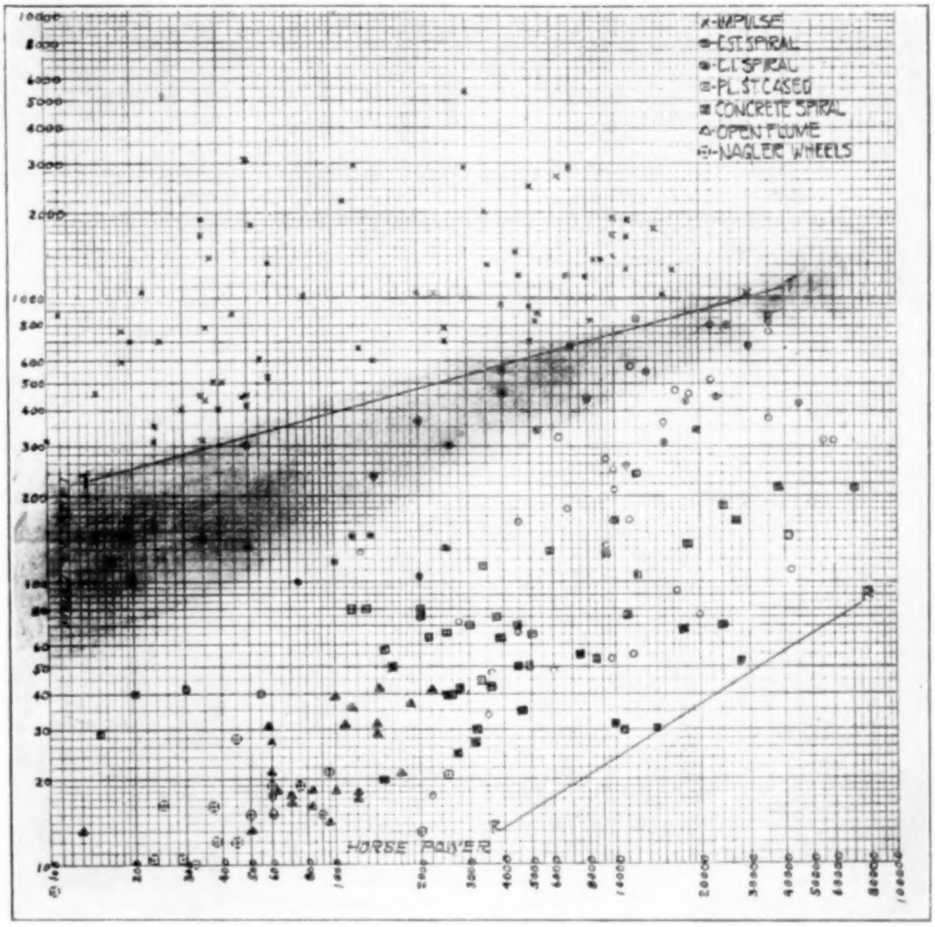

Fig. 7 A Plotting of the Entire Hydraulic-Turbine Field, Embodying Practically All of the Noteworthy Plants Ever Built

(Points above line T-T represent impulse units, practically all of them being of the tangential type. Line R-R represents approximately the limit of reaction units. The shaded portion adjacent to line T-T represents a field lying between the tangential impulse and high-head reaction fields and at present disadvantageously developed by them. This is the field to which the proposed cross-flow type of wheel is particularly adapted. Impulse-wheel horsepowers are plotted for one jet.)

The name "Cross-Flow" was selected after considering such terms as "vortex impulse" or "annular impulse" (on account of the ease with which so many jets may be used as to form a continuous whirling jet); and "axial impulse," "radial impulse," "mixed-flow impulse," etc., for reasons connected with the noticeable feature of various mechanical arrangements. "Cross-flow" seemed especially appropriate not only because it so aptly describes the direction of flow across the wheel but because it so distinctly defines the direction of flow as contrasted to that in the present wheels which are universally known as the tangential type.

Advantages of the Cross-Flow Type of Impulse Wheel

The cross-flow wheel, aside from its advantage in speed, automatically corrects one of the defects that contributed greatly to the failure of single-flow impulse turbines such as the Girard and other partial wheels. The "backing" of water in the wheel resulting in its being dragged around with the wheel and ultimately discharged at wheel velocity at about half its original velocity, results from impact due to the large angle between the relative water path and the surface of the bucket at the point of impact [point B, Fig. 6 (b)]. The slower the speed of the bucket, the greater the curvature and consequently the greater the impact and "backing" loss.

With higher speeds the bucket becomes flatter and the "backing" loss with its poorer efficiency and greater tendency to pit is more and more reduced [see B, Fig. 6 (d)] without resorting to the undesirable expedient of increasing the number of buckets. Inspection of the successive diagrams of Fig. 6 indicates how the angle of impact between the jet and bucket is successively reduced as the speed is increased and the bucket correspondingly flattened. The author believes that this principle can be utilized to eliminate

or at least reduce the efficiency losses and pitting troubles experienced with the Girard types, and with it there will be a rapid return to radial and axial and even conical or mixed-flow impulse wheels. In combination with nozzles designed to deliver circular jets with their higher efficiencies and more uniform distribution of velocities cross-flow wheels can be applied to a considerable portion of the field for which there is at present no design except the disadvantageous multiple-runner or multiple-nozzle types. For low heads and small powers or where efficiency may not be of the greatest importance the circular jet may be dispensed with and rectangular jets arranged to partly cover the wheel periphery (partial turbines), or even solid annular jets (full turbines) may be utilized.

The cross-flow wheel does have an inherent disadvantage from an efficiency standpoint. The relative velocity between jet and bucket is the lowest (50 per cent of spouting velocity) in a tangential wheel and higher in the cross-flow types; for example, for a 100 per cent coefficient the relative velocity is practically twice what it is in a tangential wheel. This, of course, involves a greater friction loss, but in actual practice this may be offset by reduction of windage and splash losses and particularly by the possibility of developing more power in a given working volume of space swept by the buckets than it is possible to do with the tangential type (see Fig. 5).

Vertical impulse wheels have certain mechanical advantages when large capacities are considered, these being similar to those which underlie the popularity and economies of the vertical reaction units and in addition incorporate the possibility of feasible mechanical arrangement of more jets than possible with horizontal types. Engineers experienced with impulse work, however, are familiar with the tremendous disturbances that exist even in horizontal wheels having but a single jet and can appreciate the condition that must exist when several jets are played on one wheel. When it is further considered that all the upwardly discharged water that falls or is spattered back into the path of the buckets must again leave the wheel at practically wheel velocity or half its own initial velocity, and that this represents a total loss, the desirability of getting the water positively and clearly away from the wheel is apparent. The cross-flow design, embodying as it does the feature of single direction of flow through the wheel without "backed" water losses, lends itself admirably to this arrangement. This is particularly so as in extreme cases multiple or annular jets may be used without injurious interference, as each elemental jet uses such a relatively small portion (see Fig. 5) of the periphery as contrasted to the tangential type where each jet needs for its working space a chord subtending a relatively larger angle.

Fig. 7 presents the entire field of hydraulic-turbine practice. On this diagram are plotted the heads and horsepowers of practically every water wheel of note ever built, particularly those that extended the developed field in any direction, regardless of type or nationality. The upper field above the line T-T (points marked $\times$) are of the impulse type. Those below the line T-T are of the reaction (Francis or suction) types. Portions below, to the right, or above the limits of the field of plotted points are as yet undeveloped.

Undesirably low generator speeds have so far restricted further development below and to the right of the line R-R. Size of parts and transportation limitations retard although do not prohibit extension to the right above the line R-R. The infrequency of points at the top of the sheet arises from the difficulties arising from extremely high pressures (above 3000 ft. for example), the difficulties in securing suitable material for withstanding high stresses, and the comparative infrequency with which such high-head conditions are encountered. Undoubtedly the next few years will see units of 100,000 hp. capacity, and possibly more heads in the neighborhood of 3000 ft. 70,000-hp. impulse units for 2150 ft. head are even now being worked out in detail.

The significance of Fig. 7 so far as this paper is concerned lies in the comparatively undeveloped gap existing between the impulse and reaction types. This gap exists by reason of the difference between the highest impulse characteristic speed (about 5 ft-lb. units) and the lowest reaction characteristic speed (about 10). Even the multiplication of jets and nozzles incorporated in

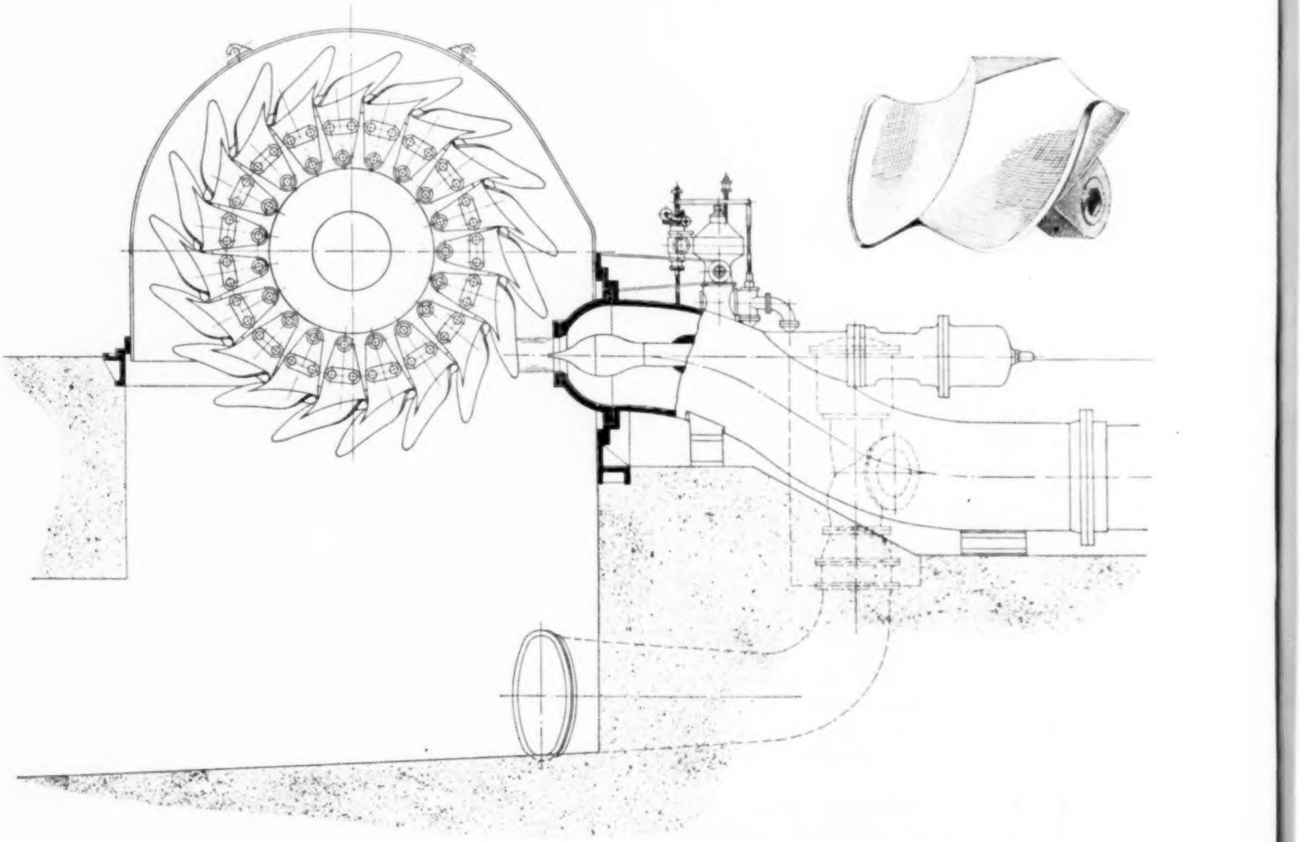

Fig. 8 Suggested Application of the Cross-Flow Principle to an Impulse-Wheel Unit of Conventional Arrangement

(The large angle of incidence shown is obtained by simply raising the jet above a tangential line so that it flows in a more nearly radial direction. The sketch at the upper right of the figure shows a bucket for use with a cross-flow wheel and designed to illustrate dividing the discharge and equalizing the thrust by a splitter.)

most of the larger-capacity impulse units has failed to bring the two fields together.

The field of head and capacity now covered by impulse wheels of the tangential type needs extending only a limited amount. This extension is indicated roughly by the shaded section of Fig. 7, this section lying along and below the line *T-T*, between the fields to which tangential impulse and reaction wheels are well adapted. Going beyond this neutral ground in a lower direction, involves competition with the reaction-type runners that give economical generator speeds with lower water velocities and better efficiencies. It is to this intermediate field that the cross-flow impulse design is peculiarly adapted, as with it characteristic speeds of 5 to 20 are readily obtainable with single jets as shown in the upper shaded area of Fig. 2 and curve 14 of Fig. 4. With multiple or annular jets even higher speeds are possible, theoretically up to over 100 from curve 16, Fig. 4. There will probably be no commercial demand for such extreme speeds using the cross-flow principle as the reaction type covers this field satisfactorily and with more desirable water velocities. The greater simplicity of the impulse type may, however, make those high-speed types work out advantageously with small or auxiliary units.

As in all simple developments, a detailed search of prior art shows numerous designs that might be construed to anticipate the cross-flow principle. These comprise various designs from the earliest forms of flutter wheel where water from a trough falls on a paddle wheel, up to and including various forms of Jonval wheels, which may have been set above tail water, and through the various designs of Girard and Schwankrug wheels. All of these installations with which the author has been familiar have a flow other than tangential, not by reason of its advantage but because of certain desired mechanical arrangements and in spite of the acknowledged disadvantage of departing from the tangential arrangement. This fact is indicated by the numerous details of design which indicate the extreme measures which were used to secure flow as nearly as possible tangential. Exhaustive search has indicated no single instance where free circular jets, adjustable in size, have been purposely directed against the buckets at angles greater than 45 deg. with a tangent.

That the problem of securing higher specific speed in the impulse field is one of real commercial significance is indicated by the fact that such variety of expedients have recently been used to raise speeds. These efforts parallel with surprising exactness the multiple-runner craze that dominated the reaction field during the years 1900 to 1910, resulting from the attempts of water-wheel builders to keep pace with electrical designers in speeds of units. The reaction program was confined at first to using multiple runners, as the entire periphery was used at the start. Later the reaction development followed lines of widening the inlet to the runner, increasing the velocity of the water, and finally in increasing the relative wheel velocity.

The impulse-wheel designer started with the limit of water velocity, has gone through the stages of multiple jets, then multiple wheels, and is now at the point of facing the use of larger percentages of wheel periphery (larger inlet area) and higher wheel speeds.

The analogy to the history of reaction-wheel development is perfect, even to the point where for a large field of head and capacity the electrical designer is ahead of the wheel designer in speed. With the development of high-speed impulse wheels there should be experienced a return to the single wheel and possibly to the vertical shaft setting, the two features that so completely dominated the tremendous advances experienced in the reaction field in the past decade.

This does not mean that the tangential wheel is to be displaced, rather that it should be supplemented. For a certain range of head and capacity—a very wide range at that—it affords a perfect solution, one that harmonizes with desirable generator speeds with excellent efficiency and the utmost simplicity and durability.

It is for lower heads and larger capacities that new designs are needed. While the elements of the machines themselves are not subjected to mechanical complication or hydraulic losses as serious as those which caused the multiple-runner reaction turbine to be superseded by the single vertical arrangement, the general complications of water passages and governing mechanisms and possibilities of flow interference are certainly such as to be expensive and undesirable. If the history of the progress in reaction wheels is any guide, future developments in the impulse field will return to single runners of higher characteristic speeds just as the multiple-runner reaction wheels yielded first to higher-speed mixed-flow wheels and later to the still higher-speed axial-flow or suction wheels.

Fig. 8 is shown as an example of proportions and possible details of a unit based on the cross-flow principle for conditions of reduced head and increased capacity comparable with those which incur multiple jets or wheels. This is shown as indicating a possible trend in impulse design based on investigation of modern commercial needs and analysis of the hydraulic and mechanical features involved. It is not suggested that initial installations should be made for such large capacities and heads without first obtaining more operating data than are now available on the new type proposed. It is believed, however, that the low-head extension of the field of impulse wheels, particularly for small and moderate capacities, is warranted immediately.

The main purpose of this paper is not to present a complete solution of problems confronting the designer of impulse wheels, nor is it intended even to present the new type as being completely worked out. It is intended to draw attention forcibly to the possibility of departing from the orthodox tangential flow and 50 per cent coefficient, departing even from the specter of practice, precedent, usage, and textbooks without violating perfectly sound hydraulics. If the only too common tendency to get in a rut and stay there is lessened, the author will be more than satisfied.

Power from Tides

THOSE interested in power generation from tides might do well to read Hydro-Electric Engineering, vol. 2, edited by A. H. Gibson (compare review in *Engineering*, Feb. 16, 1923, p. 193).

In the simplest manner the author states the principles on which alone a scheme can prove a commercial success, and he is under no misapprehension as to the difficulties that any proposal will have to face and overcome. He submits the loose and somewhat optimistic views of irresponsible guides to the stern arbitrament of actual statistics drawn from the published balance sheets of Canadian companies, who have had the advantage of acquiring land at prairie value, and little to fear in the way of active competition. It is idle to point out that the nation is allowing a valuable asset to run to waste by neglecting tidal movement while the coal fields are being extravagantly depleted, unless it is explained how that force is to be utilized. At present there is no market for such power; only new undertakings can utilize the energy, and there are but few signs of these forthcoming.

Apart from the commercial success there are, however, many interesting problems that arise in considering the novel scheme of harnessing the tides. Some of these, more particularly concerned with hydraulics, were discussed in the earlier volume. Dr. Gibson now carries the inquiry a stage further. Matured reflection has convinced him that multiple-basin systems must be excluded as outside the limits of practicability, and that the only schemes likely to lead to a successful issue must be based on the use of a single basin developing power on both rising and falling tides, or on the outflowing tide only. Assuming that the tidal basin has an area of 1 sq. mile, that the water surface is sensibly level at all stages of the tide, that the range at spring tides is 42 ft., that 5 hr. are occupied in rising and 7.5 in falling, that at neap tides the range is 16 ft., and that the time consumed in rising equals that in falling, it is possible to form a very definite idea of the power that would become available. Three cases may be considered: First, working on a falling tide only—the least favorable case—and making the usual allowance for loss in storage supply, the output may amount to 7680 b.hp. continuous 24 hr. working. In the second case, operating on rising and falling tides under natural head, the output rises to 12,400 b.hp. Finally, if the scheme be arranged to work with rising and falling tides with constant rates of rise and fall in basin, a maximum output of 13,150 b.hp. is attained if all the energy is absorbed. In these estimates it is assumed that the primary turbines have a mean efficiency of 75 per cent, but this value may be too high, for under the extreme variations of head the efficiency of any constant-speed turbine falls off rapidly.

Lignite Char: Its Production and Possibilities

By O. P. Hood,[1] Washington, D. C.

Lignite char is lignite which has been dried and distilled in an oven especially designed for the purpose. About two and one-half tons of raw lignite reduce to one ton of char, the heating value of which is about 12,000 B.t.u. per lb. While raw lignite can be used satisfactorily in large steam-raising operations the author believes that the search for a means to improve the fuel must continue. American lignites do not briquet well without the addition of a binder, and the Bureau of Mines has therefore been led to investigate the possibilities of an inexpensive carbonizing process and the use of the resulting lignite char direct without briquetting. This process is briefly described in the paper.

The greatest difficulty with our lignite is the fact that in nearly every district where it should be the natural fuel it is put in competition with high-grade fuel. We are all spoiled by having been blessed with an abundance of the best, so that we are impatient with the limitations of lower-grade fuels. If we had been obliged to go down 2000 ft. or more and win good coal from thin seams in scattered districts as they do in Europe, we would have long ago worked out a successful technique for utilizing our lignites. Canadian and North Dakota lignite must compete with anthracite and with Pittsburgh and Illinois bituminous coal; our Texas lignite must compete with gas, oil, and Oklahoma bituminous coal. It is evident, however, that there must be a price at which the lower-grade fuel will begin to be attractive. In round numbers the ratio is somewhere in the neighborhood of half the price of good coal. With the rising price of bituminous coal we are fast approaching the time when this ratio will be common.

The handicaps of lignite are well known, but not always properly valued. The heating values of high-moisture fuels are somewhat misleading. The heat carried by the moisture is recovered and measured in the calorimeter, but is not fully utilized in a boiler furnace. The B.t.u. ratios, therefore, do not give the relative possible steaming values of the fuels if comparison is made between a high-moisture lignite and a low-moisture bituminous coal. Although the ash percentage may be low, there is usually a larger total amount of ash to handle in a plant using lignite. The fusing temperature of the ash is usually low, making high rates of combustion difficult and requiring larger grate areas and furnace volumes than with higher-grade coal. Notwithstanding these handicaps, with present technique, raw lignite can be used in large operations, and good efficiencies and reasonable capacities can be obtained. The problem is largely an economic one. When raw lignite is cheap enough in comparison with better coals it will be used in large steam-raising operations.

Improvement of Raw Lignite for Fuel Purposes

The search for a means to improve the fuel, however, must continue. A fuel classed as lignite in northern Bohemia, and weathering much as does our lignite, is as carefully prepared for market as is our anthracite. Seven prepared sizes are offered to the market. Raw lignite can probably be somewhat improved for steam raising by sizing the product more closely than is common practice. It is probable, however, that an improved lignite product must first cater to a special trade that will pay a special price. This is illustrated by the vision that has been so frequently held of improving the lignite by some process involving briquetting. Unlike the German "Braunkohle," our lignites do not make a stable and satisfactory briquet simply by drying the lignite and briquetting by heat and pressure. They lack sufficient inherent binder to consolidate and waterproof the mass. The necessary added binder increases the cost and hardly improves the quality. A quite satisfactory fuel can, however, be made by briquetting lignite char, and it is probable that some day such a fuel will be in common use.

There have been hopes that through the recovery of by-products sufficient credits might be obtained to materially lessen the cost of briquets. Profit can be shown on paper, but such a process is essentially a large-scale operation requiring a large investment and very substantial financial backing by those familiar with technical enterprise. It is difficult, therefore, to start such an industry, for there is no opportunity to begin small and grow up, returning profits into an improved plant. Capital familiar with technical enterprise finds less hazardous ventures, and capital unfamiliar with such enterprise is apt to be misled and lost.

Lignite Char and Its Possibilities

With these facts in mind, the United States Bureau of Mines is investigating the possibilities of a somewhat different program which has for its main features an inexpensive carbonizing device and the use of the lignite char direct, without briquetting. If a market for the char can be developed, and the small mine can produce char, there would be provided means for a natural evolution of an industry that in time might realize the larger vision of briquetting and recovery of by-products. Lignite char can best be described in a few words as a fuel rather near in analysis to anthracite coal, but softer, with a little more volatile matter, and thus kindling easier. In size it grades from pea coal to smaller sizes, and is a stable product. Whether a market can be developed for such a fuel at prices around five dollars a ton at the mine, remains to be shown, but it is at least encouraging to know that Germany used last year 400,000 tons of similar material for domestic heating and cooking. This fuel burns well with natural draft where a thin fuel bed, about $1^1/_2$ in. in thickness can be maintained. Base burners, cook stoves, and other heaters can be adapted to use the fuel satisfactorily. The Germans have developed a special stove, burning the fuel on a bed of ash in an enclosed drawer. There is no loss of fuel in the ash and our lignite char used in such a stove heats an oven sufficiently for baking operations and will boil water. It makes a very clean fire, is smokeless, and the char is clean to handle. It is, however, slow in getting under way as compared to a gas range.

Production of Lignite Char

To produce the char a very simple oven has been devised that greatly reduces the investment from that needed for ovens heretofore proposed. If lignite be passed through a combustion zone, moisture is first driven off; then combustible gases are distilled, and finally the solid carbon is burned. There is a considerable shrinkage in volume and a complete absence of caking quality. These steps are fairly distinct one from the other, so that the flow of lignite through the combustion zone may be so regulated that but little of the fixed carbon is burned. The combustion zone can be maintained by burning some of the distilled gases within the moving mass of lignite, and such direct heating is more efficient than where heat must be transmitted through refractory walls. The hot gases of combustion also pass through the mass, driving off the moisture and departing fairly cool. It is something like an open-top lime kiln. The process has proved simple and efficient. Of the gas driven off, much of it is used in the combustion zone, and in addition, less than 5 per cent of the weight of the original lignite is burned. That is to say, the fixed-carbon loss in the process for drying and distilling is lower than is usually found for drying alone where separate driers are used. Passing the combustion zone the lignite enters a lower section protected from the air, where it cools and is then removed. The char obtained by such a process may, of course, be briquetted.

An oven of this sort was operated at Grand Forks, North Dakota, during the past summer, and about 400 tons of various North Dakota lignites passed through. In February about 100 tons of Saskatchewan lignite was tried to discover whether this presented any special problems.

About two and a half tons of raw lignite reduce to one ton of char, and the heating value is about 12,000 B.t.u. per lb. The moisture is very low, and the char can be stored without danger of fire or degradation in size. Where the freight charge is heavy it would be an advantage to ship char instead of raw lignite.

[1] Chief mechanical engineer, U. S. Bureau of Mines, Mem. A.S.M.E.
Contributed by the Fuels Division for presentation at the Spring Meeting, Montreal, P. Q., Canada, May 28 to 31, 1923, of The American Society of Mechanical Engineers. All papers are subject to revision.

Aluminum Bronze as an Engineering Material

By W. M. Corse,[1] Washington, D. C.

By aluminum bronze is meant, not the gray-white metallic coating used on radiators, but rather a strong, reliable metal resembling 0.35 per cent carbon Swedish bessemer steel to a remarkable degree. The color, of course, is different, but the mechanical properties are much the same. It resists alternations of stress unusually well and is superior to nearly all of the non-ferrous alloys except monel metal in this respect. Aluminum bronze is essentially 90 to 92 parts of copper and 8 to 10 parts of aluminum, while monel metal is approximately two parts of nickel to one part of copper. Naturally, the two metals behave differently with respect to corrosion, but they are much alike in strength and hardness. Both hold their strength much better than other alloys when exposed to elevated temperatures, a fact of importance to the steam engineer.

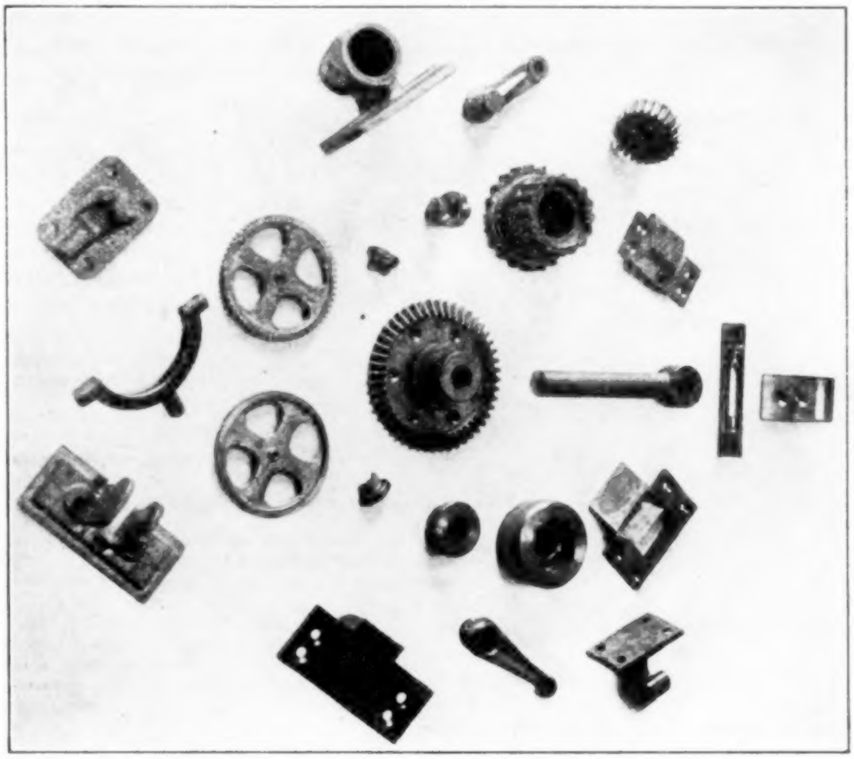

Fig. 1 Intricate Die Castings Made from Aluminum Bronze

Properties

Aluminum bronze is about the color of 10-carat gold, has a tensile strength of 70,000 lb. per sq. in., and an elongation of 15 per cent. Its Brinell hardness number is 100–110. These properties place it in the class of strong bronzes suitable for the most exacting service. Particular mention should be made of its resistance to alternating stress or fatigue. "In the Landgraf-Turner endurance-testing machine the aluminum bronzes resisted 4500 blows before fracture, while the manganese bronze resisted about 500."[2]

"The results show clearly that aluminum bronze, in spite of its comparatively low yield point and proportional limit as shown in a tension test, is far superior to manganese bronze in endurance of alternating stresses or resistance to fatigue, and therefore its life would be longer in practical use."[3]

Similar comments were made by the authors of the Eighth Report to the Alloys Research Committee of the British Institution of Mechanical Engineers. Many practical tests have confirmed all of the above statements, so that an engineer in search of a metal to withstand fatigue should consider aluminum bronze. Such parts as those for air hammers and foundation bolts for drop hammers are good examples.

The other strong bronze, manganese bronze, has many admirable properties, but it is not adapted for bearing surfaces. Aluminum bronze has proved its worth in this field in such parts as worm-wheel gears. Every day's output of 1000 Ford trucks carries 12,000 lb. of this metal in gears. Extensive tests of aluminum-bronze gears against phosphor bronze in one-man tanks during the war proved the superiority of the former for this most difficult service.

Almost constant trouble was experienced with large spur gears on the locomotives on the Mt. Washington Railway until aluminum bronze was tried. Its service there has proved eminently satisfactory.

Pickle-crate equipment made of aluminum bronze has been found to withstand the action of sulphuric acid well. This fact, combined with its strength, fits it for this purpose. The property of resisting abrasion is useful for gears, but aluminum-bronze trolley wheels have been found to give remarkable service for the same reason. The toughness of the alloy is useful here as well, because the effect of a severe blow can be readily corrected under the hammer without breakage.

Adaptability

Aluminum bronze is tough when cold, but is more so when redhot. This property makes forgings possible and also helps materially in the manufacture of die castings from this metal. A number of intricate die castings are shown in Fig. 1. These are not samples but are taken from regular production runs of lots of 10,000 or more. The process is a commercial one, for the dies are made so that they will withstand at least 10,000 openings in most shapes. The solving of the die problem is of equal importance with the metal problem, for one can not proceed without the other. The property of toughness is useful also in Jordan bars for beating engines. With its freedom from corrosion, the tough aluminum-bronze Jordan bar has been an increasing success in the paper industry.

Machinability

Many excellent properties of aluminum bronze have been mentioned, but it has its drawbacks. First, at least at present, is the difficulty of machining, compared with other bronzes or brasses. This does not mean that it cannot be machined readily under proper conditions, but that, compared to ordinary brass or bronze, its toughness makes it more difficult to handle in the machine shop. Sharp tools, kept so, of the proper angle are essential to success. Ample lubrication is necessary. With these precautions a most excellent job can be done as is evidenced every day at the Ford factory in Detroit. Aluminum bronze most nearly resembles mild steel in its machinability.

When one sees the stacks of golden-bronze worm wheels in the gear department of the Ford Company and examines the polished surface of the gear teeth left after the machining operation, there can be no doubt that aluminum bronze as an engineering material has arrived and that its excellent properties have been made available to the engineer because scientific research solved the problems of its manufacture in the foundry.

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[1] Chairman, Division of Research Extension, National Research Council.

[2] Aluminum Bronze Alloys, W. M. Corse, Trans. Am. Inst. Metals, 1915, vol. 9, p. 202.

[3] Aluminum Bronze, Some Recent Tests and Their Significance, Corse and Comstock, Proc. Am. Soc. Testing Materials, 1916, vol. 16, part 2, p. 118.

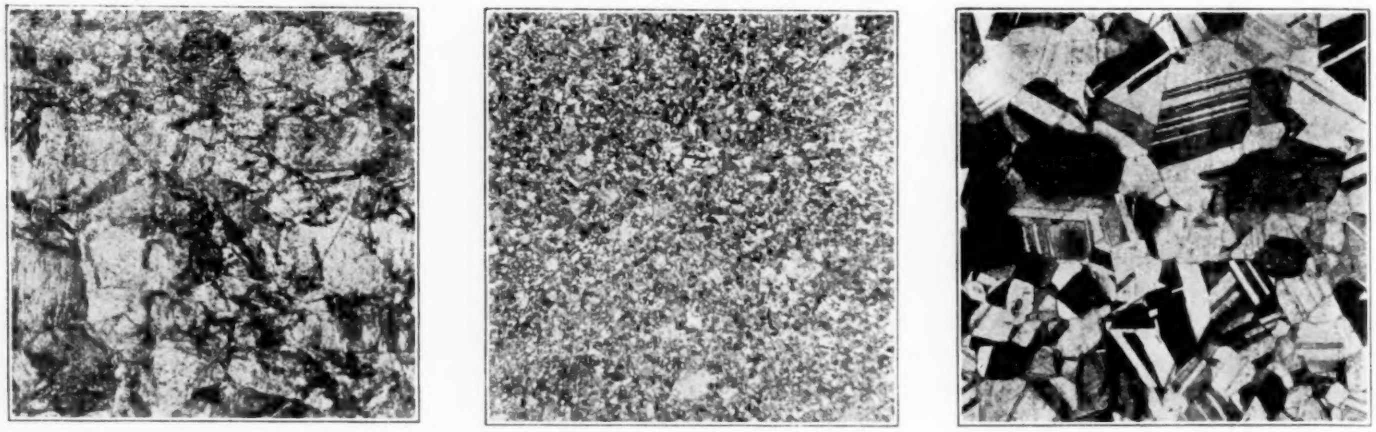

Fig. 2 Hard Fig. 3 Light Annealed Fig. 4 Soft Annealed

Figs. 2, 3 and 4 Photomicrographs Showing the Structure of 8 Per Cent Aluminum Bronze. Magnification, 75 Diameters
(Percentage composition: Copper, 92.46; iron 0.20; aluminum 7.29.)

The second objection to aluminum bronze might be its cost, which is about 25 per cent more than that of brass or bronze. But when compared to special bronzes with somewhat similar properties the difference in cost disappears.

Like all high-grade metals it must be manufactured under careful supervision, and more than usual care must be used in the casting shop and foundry.

Manufacture

Charles Vickers, in his book, Metals and Their Alloys, just published, devotes a chapter to aluminum bronze and goes into the manufacture and properties of the alloy thoroughly. Vickers devised the flux or degasifier that made the casting of aluminum bronze a commercial success in the sand foundry, and to him we owe much because of his untiring efforts in investigating the complicated problems connected with its manufacture. Vickers patented an alloy of copper, aluminum, and iron which shows markedly improved properties over the alloys without iron. Previously iron was considered detrimental in the manufacture of aluminum bronze, but as a result of Vickers' work many combinations of copper, aluminum, and iron are possible and enable us to make a series of alloys with widely varying properties.

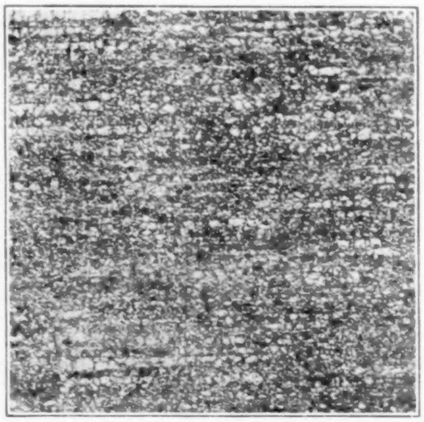

Fig. 5 Structure of Hard 8 Per Cent Aluminum-Bronze Rod. Magnification, 75 Diameters

George F. Comstock has investigated these alloys metallographically and published numerous articles of value on the subject. The author has had the privilege of being associated with the work of both Vickers and Comstock from the beginning, and has assisted in the commercial development of aluminum bronze since 1914. He heartily agrees with the following quotation from Erwin S. Sperry,[1] which, when written in 1905, was a prophecy, but has since become an accomplished fact.

> When a good casting of aluminum bronze is made, it is superior in every way to manganese bronze. I do not say this because I am prejudiced in any way, for I have had fully as much to do with one of these alloys as another; but for the reason that I firmly believe aluminum bronze has met with defeat, not because of its lack of strength, not from its unsuitability for all the work which manganese bronze will do, not on account of its excessive cost, but for the reason that no one has yet mastered its casting so that successful castings may be continuously turned out. When this has been done, and at some future time it will be accomplished, aluminum bronze will replace manganese bronze as it has been replaced itself.

The addition of manganese to the copper-aluminum alloys was investigated by W. Rosenhain and C. A. H. Lantsberry at the National Physical Laboratory, Teddington, England, and described by them in the Ninth Report to the Alloys Research Committee of the Institution of Mechanical Engineers of Great Britain. In general, the addition raises the yield point and tensile strength without diminishing the ductility.

Wrought Aluminum Bronze

Most of the remarks thus far have referred to cast aluminum bronzes, but as rolled or wrought alloys are commercial products and are manufactured in large quantities the author quotes below from W. H. Bassett, whose experience with these alloys gives authority to his statements.

> Aluminum bronze has a high resistance to corrosion, and is used principally when this property coupled with a high tensile strength and hardness is required.
>
> Copper-aluminum alloys can be made in wrought form in any proportions up to an aluminum content of approximately 10 per cent. Three alloys, however, are used principally. These contain 5, 8, and 10 per cent aluminum, respectively. All three alloys hot-roll easily, and these same remarks would apply to the cold rolling of the 5 and 8 per cent. The 10 per cent aluminum bronze does not cold-roll readily, in fact would not be considered a cold working alloy.
>
> The 5 per cent aluminum bronze is furnished principally in the form of sheets. It has when cold-rolled, a tensile strength as high as 100,000 lb. per sq. in., depending upon the degree of hardness or cold rolling, and an elongation in 2 in. of 10 per cent. When annealed this alloy has a tensile strength of 55,000 lb. per sq. in. with an elongation of 75 per cent in 2 in. This high elongation for annealed 5 per cent aluminum bronze is characteristic of the material, and it is rarely equaled in the other non-ferrous alloys.
>
> The 8 per cent aluminum bronze is manufactured extensively in both rod and sheet form, and is supplied when resistance to wear is also required in connection with the other general physical properties given for aluminum bronze.
>
> This alloy is in more general use than any of the other wrought aluminum bronzes. In the form of sheets when cold rolled the tensile strength may be as high as 130,000 lb. per sq. in., with 4 per cent elongation. When annealed this same material has a tensile strength of 60,000 lb. per sq. in. and an elongation of 60 per cent. The generally high tensile strength makes this material very valuable for many engineering purposes.
>
> Micrographs 1, 2 and 3 [Figs. 2, 3 and 4] show, respectively, the structure of 8 per cent aluminum bronze sheets hard or cold-rolled, light annealed, and soft annealed. These particular samples had the following physical properties:

Sample No.	Temper	Tensile strength, lb. per sq. in.	Elongation in 2 in., per cent
1	Cold rolled	102,000	7
2	Light annealed	77,000	36
3	Soft annealed	61,000	62

> Rods in 8 per cent aluminum bronze can also be supplied with approximately the same physical properties as sheet metal. However, it is customary to furnish them in a medium temper with a tensile strength of about 85,000 lb. per sq. in. and an elongation of 30 per cent. Micrograph No. 4 [Fig. 5] shows the structure of a rod of this nature.
>
> The 10 per cent aluminum bronze has, of course, the highest tensile strength and lowest elongation of this series. Owing to the fact that it can be only very slightly cold worked, it does not have the range in physical properties as shown by the other alloys. Its tensile strength may be taken as 75,000 lb. per sq. in. and elongation as 25 per cent. There is not a great demand for this class of material, but when supplied it is usually furnished in the form of hot-rolled sheets, hot-rolled or extruded rods, and extruded

(Continued on page 331)

[1] *Brass World*, vol. 1, p. 400.

Refinery and Rolling Mill for Monel Metal, Huntington, W. Va.

By W. L. WOTHERSPOON,[1] NEW YORK, N. Y.

This paper describes the steps taken in selecting the site for the location of a mill for rolling monel metal. The economic problems involved are stated and the facts leading to their solution are given. The remainder of the paper deals with the layout of the plant, emphasizing certain features of design that are of particular interest.

MONEL metal consists of 67 per cent nickel, 28 per cent copper and 5 per cent other elements, and is a natural alloy. In appearance it resembles nickel and in tensile strength it is comparable with steel, while its resistance to corrosion is very high. Its resistance to acids together with its physical and working qualities (for it can be cut, rolled, welded, machined, and forged) make a combination of properties which are not to be found in other common metals.

Monel metal is produced at the refinery in shot, pig, and ingot from monel-metal bessemer matte consisting of approximately 56 per cent nickel, 24 per cent copper, and 20 per cent sulphur, the iron content being about 0.4 per cent. The mill product consists of forgings, merchant and sheet bars, wire rod in coils, and sheets.

The International Nickel Company, in order to provide facilities for the increased requirements of monel metal, has recently completed a refinery and rolling mill at Huntington, W. Va. The project may be considered as new industry; active development of markets for monel metal having only been undertaken during the last few years, during which requirements have been met by arrangements with various steel mills for production of the abovementioned products from ingots supplied from the Bayonne, N. J., refinery of The International Nickel Company.

The purpose of this paper is to describe the investigation leading to the location of these works, together with certain features of their design and construction, and to give information on the products manufactured, all of which is believed to be of general interest to engineers and manufacturers.

Investigation Regarding Location for Works

A general survey of requirements in order to prepare preliminary plans, and estimate the costs and acreage necessary, was first made, as a result of which the following conclusions were reached:

a That existing and prospective business for monel metal justified the estimated capital expenditure of approximately \$3,000,000 for a rolling mill to produce rods and sheets

b That the potential markets for monel metal and other alloys were such that the plant should be laid out with provision for considerable expansion

c That natural gas, being practically free from sulphur, was the ideal fuel for heating purposes. Should it be necessary to utilize producer gas, the estimated capital expenditure for plant and equipment would be increased approximately by \$200,000

d That the particular disposition and service of the merchant and sheet mills was such that individual electric drive, with gear reduction where necessary, would be best

e That purchased electric power was preferable, and if not available capital expenditure would be increased by approximately \$750,000

f That at least twenty, and preferably up to fifty, acres were advisable for a site.

With the survey of requirements and the conclusions available, the following districts were given particular study: Bayonne, N. J., Buffalo, N. Y., Baltimore, Md., Pittsburgh, Pa., and Huntington, W. Va.

[1] Consulting engineer, International Nickel Co. Mem. A.S.M.E.

Presented at the Annual Meeting, New York, December 4 to 7, 1922, of The American Society of Mechanical Engineers. Abridged. All papers are subject to revision.

Although the ores and bessemer matte from which monel metal is produced come from The International Nickel Company's mines and smelter in the Sudbury district of Ontario, Canada, and there had within a few years been constructed by the company a refinery for nickel products at Port Colborne, Ontario, economic factors such as tariff, fuel, markets for finished products, etc., were such as to confine the detailed study of locations for these new works to the eastern half of the United States.

Bayonne, N. J., was considered, as The International Nickel Company's largest refinery had been established there many years and it was thought the rolling mill might be an addition to the existing works. The investigation resulted, however, in the Bayonne refinery being discontinued, the plant dismantled, and one of the most valuable sites on New York Harbor made available for some other industry for which the economic conditions are excellent, but which are unfavorable for the refinery and rolling

Fig. 1 General View of Plant from C. & O. R. R., June, 1922

mill. Important changes and extensions have therefore been made at the Port Colborne refinery so that nickel in all forms can be refined in Canada, and the refinery with rolling mill has been constructed at Huntington, W. Va., for the production of monel metal, malleable nickel, and other specialties.

The following is a list of the economic factors investigated, together with the comparative ratings given them:

Labor	250	Climate	50
Fuels	330	Supplies	60
Power	100	Taxes and laws	20
Living conditions	100	Site (cost and quality)	10
Transportation	50	Construction cost	20
Water supply	10		

The following general conditions apply to the district of Huntington, W. Va., which are considered especially suitable for the industry described:

Labor. Labor is made up of 95 per cent English-speaking Americans, both common and skilled, with good records in the territory in diversified industries; the turnover is light and a majority of the workers own their homes.

Fuels. A plentiful supply of natural gas for manufacturing and domestic purposes, from public-utility companies, is available at a cost of from 18 to 19 cents per 1000 cu. ft. (1100 B.t.u. per cu. ft.). Investigation of developed and undeveloped gas fields indicates supply of gas for 15 to 20 years. A good supply of high-grade oil of low sulphur content is available from the local oil refinery at a present price of 5 to 6 cents per gallon delivered at plant. There is an excellent supply of high-grade bituminous steam and gas coals from local coal fields costing \$2.50 to \$3.00 per ton, delivered at the plant.

Power. Two modern central stations supply power at a cost to large industries of 11 to 12 mills per kw-hr.

Transportation. Thirteen important railroads make connections within 175 miles. The Ohio River is navigable all the year, traffic between Pittsburgh, Huntington, and Cincinnati being on regular schedule.

Water. Both river and borehole water of good quality are available, the latter at an average depth of 60 ft.

Construction was commenced in 1921 and the plant was placed in operation in June, 1922. Fig. 1 is a general view of works as of June, 1922, and Fig. 2 a plan showing their general arrangement.

Crushing, Grinding, and Calcining Departments

The matte, which is received from the company's smelter in Canada in irregular pieces weighing about 50 lb., is unloaded from

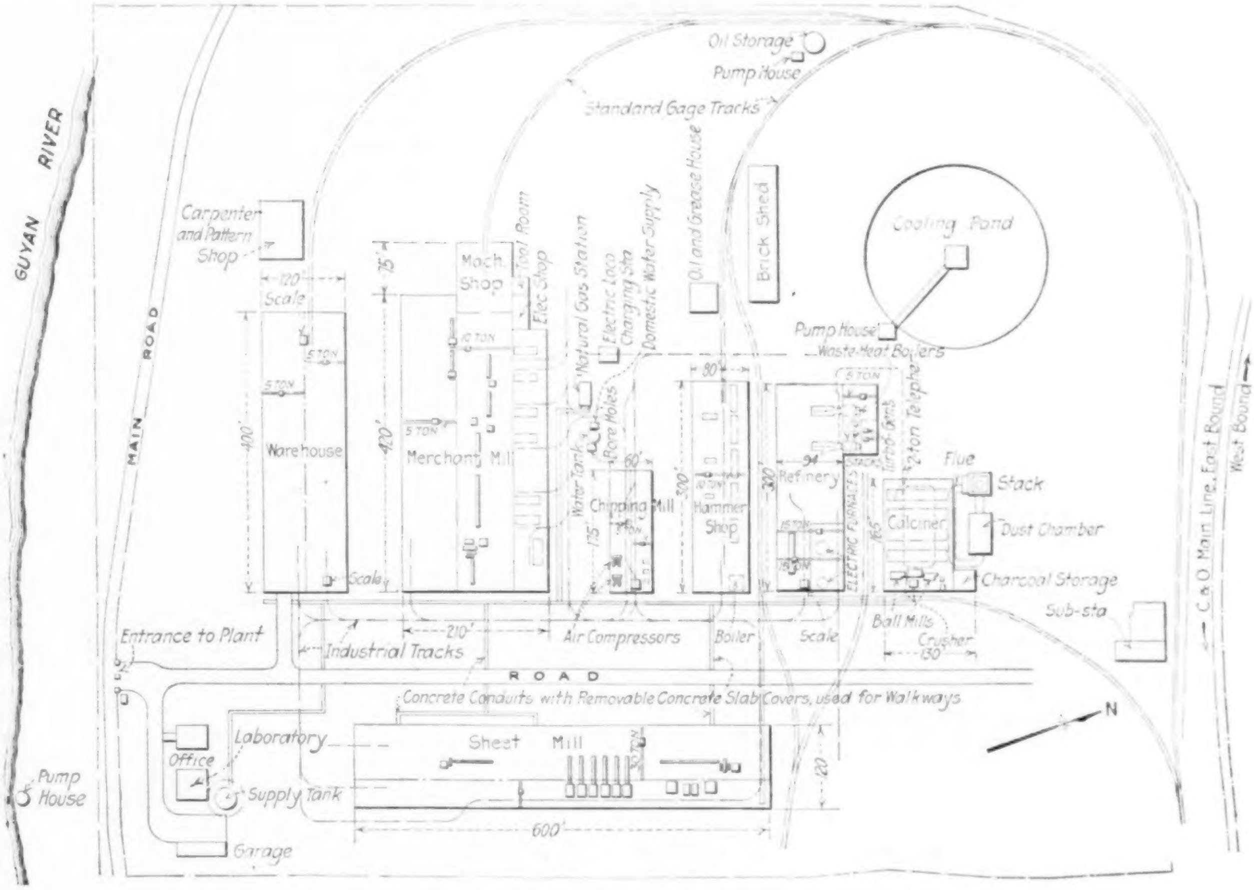

Fig. 2 Plan of Works, Showing General Arrangement

box cars and put through a 24-in. by 16-in. jaw crusher, being reduced to about $1^1/_2$-in. product, and is then fed to a No. 8 Krupp-type ball mill to be further reduced by dry grinding to pass a 16-mesh. The crusher and mill capacity is about 45 tons in eight hours, so that with the installation of a large storage bin with seven days' capacity for ground matte, this equipment can be operated intermittently to suit the convenience and arrival of cars of raw material. The crusher, ball mill, and elevators connecting them with each other and with the bin are belt-driven through a line-shaft by a 125-hp. 900-r.p.m. 3-phase high-torque squirrel-cage motor.

The ground matte is then introduced by mechanical feeders to roasting furnaces, of which there are three, the material being handled between the bins and the furnaces by 2-ton-capacity electric traveling monorail trolley hoists.

The roasting furnaces are horizontal, 80 ft. long by 17 ft. wide, and are of a modified Edwards type, the material being moved along the hearth by 32 rabbles operated by mechanical chain and gear transmission and mounted directly over each furnace. These rabbles are of cast iron with monel-metal shoes, and are hollow, being designed especially for efficient water cooling. Natural gas is used as fuel for these furnaces, the capacity of each being about 25,000 lb. per 24 hr., the sulphur in the material being reduced from 20 per cent to 0.005 per cent. The mechanism for each furnace is operated by a 5-hp. 220-volt 900-r.p.m. back-geared motor. The temperature under which roasting is accomplished varies from 2000 deg. fahr. to 500 deg. fahr. The roasted matte is discharged from the furnace by gravity into large buckets, ground charcoal being mixed with the hot material as it is discharged so that its reduction takes place from the time it leaves the roasting furnace.

Large flues with numerous baffles, facilitating the recovery of valuable dust, were given special attention in these furnaces, these connecting with a chimney 200 ft. high and 8 ft. in internal diameter at the top.

Large quantities of charcoal are used, so in this department there is provided as an extension a brick building for the storage of charcoal. Charcoal is procured locally in irregular sticks and, after passing over a conveyor provided with a magnetic pulley to extract any stray metallic substances, is delivered to a gyratory crusher, driven by a 10-hp. 220-volt 900-r.p.m. motor, to be pulverized to about $^1/_2$-in. size. A bin for the storage of crushed charcoal is provided, but the capacity is not large as it is inadvisable, due to the possibility of spontaneous combustion, to store this material in large quantities in ground form.

The cooling of the furnace rabbles takes about 100 gal. of water per min., the temperature being raised to 160 deg. fahr., which heat is utilized by pumping the water to the boiler-feedwater storage system of the auxiliary power plant.

The Refinery

The refinery department contains two open-hearth furnaces arranged for firing by either natural gas or oil. The capacity of each furnace approximately 35,000 lb. per day.

The electric traveling monorail-trolley hoist system already referred to operates between the calciner and the refinery departments, delivering the roasted monel-metal oxide from the calciner

furnaces directly to large feed hoppers mounted over the open-hearth furnaces. The telpher also delivers to the same feed hoppers ground charcoal from the crushing and grinding department and amounting to approximately 25 per cent of the furnace charge by weight. The heat utilized in furnaces of this type does not exceed 15 per cent of the value of the fuel, and a 600-hp. boiler of the waste-heat type, with superheater, is connected as close as practicable to each furnace, Fig. 3. The steam generated is used by the steam hammers and in the auxiliary power house.

There are at the side of each open-hearth furnace specially designed tanks used when making monel metal in shot form. This is accomplished by using a movable tapping spout and directing the stream of metal into water. There are also two electric furnaces, one known as the Moore, having a normal capacity of three tons per heat, and the other a Heroult, with a normal capacity of seven tons per heat. The charge floor is 100 ft. by 35 ft., of reinforced-concrete construction. The surface, where subject to rough usage, has an additional reinforcement of Irving grating.

The refinery department is equipped to produce monel-metal ingots directly from the open-hearth furnaces or from the electric furnaces. In the latter practice the furnace charge consists of pig metal produced in the open-hearth furnaces, together with selected scrap. In the work thus far done the power consumption has varied from 642 to 714 kw-hr. per ton of melted monel metal.

The Chipping Department

In order to insure a uniform hammered or rolled product of first-class quality, the outer skin of the monel-metal ingots must first be completely removed. Previous practice has been to remove this outer skin entirely by chipping with pneumatic hammers, a costly and laborious operation.

Experiments on a small scale demonstrated the economic possibilities of milling the surface of the ingots, and three high-powered milling machines belt-driven from a 20-hp. motor were installed in the chipping department. Approximately 250 lb. of metal is milled from the large ingot in an actual cutting time of 2 hr. 40 min. The total time to finish the ingot, including resetting of tools, turning and reclamping of ingots is 4 hr., thirteen operations being required. Eight-inch mills are used of special design with extra heavy steel bodies, case-hardened chip breakers, and ten inserted $1^1/_4$-in. by $^3/_4$-in. high-speed-steel blades. The blades are set in the body so that the rake angle which the face of blade makes with a radial line is 15 deg. Cutters of special design are used to mill the corners of the ingots. The face mill is run at 16 r.p.m., taking $^1/_4$-in. depth of cut with feeds of $4^1/_4$ in. and $4^5/_8$ in. per min. Angular cutters are run at 38 r.p.m. with $5^5/_8$ in. feed per min.

A skilled chipper cannot consistently chip out more than 1200 to 1500 sq. in. per eight-hour shift, or approximately two sides of a two-ton monel-metal ingot, whereas one milling machine finishes an ingot every four hours. This time will be considerably lessened on new machines with improved devices that have been ordered.

After the ingots have been milled they are taken to the chipping benches and carefully inspected. Any small defects that are not entirely eliminated by milling are chipped out by pneumatic chipping hammers. Compressed air for chipping and miscellaneous work is supplied from two direct-connected electrically driven horizontal air compressors located in a corner of the chipping building where most of the air is used. Each compressor will deliver 1030 cu. ft. per min. at 100 lb. gage pressure, and is driven by a 210-b.hp. synchronous motor running at 257 r.p.m.

The Hammer Shop

This department receives the ingots from the chipping shop. The ingots vary in size, depending upon their ultimate use, the major portion being about 13 in. by 13 in. and weighing up to 4 tons. The equipment consists of one 10-ton crane and four steam hammers of 16,000 lb., 10,000 lb., 3500 lb. and 1500 lb. capacity, respectively, together with the necessary handling equipment. There are five heating furnaces of the Stevens regenerative type, four with hearths 7 ft. by 20 ft. and one with a hearth 7 ft. by 14 ft., equipped with manual control and automatic air- and gas-regulating equipment.

Owing to the weight and toughness of monel metal the hammers are of a special design and possess some novel features. The 16,000-lb. and 10,000-lb. hammers are used for cogging or breaking down. These hammers are of a special double-frame type and are built of steel throughout. The main cylinders are bushed and valves of a new design assuring economy of steam and at the same time allowing for full control by the operator, have been embodied in their construction. The weight of one frame of the 16,000-lb. hammer is 44,000 lb., and the total weight, including the anvil, is 370,000 lb. The frames are held together at the bottom by a massive cast-steel base plate, giving a rigid construction. The ratio of the anvil weight to the falling weight is 15 to 1. Cushioned

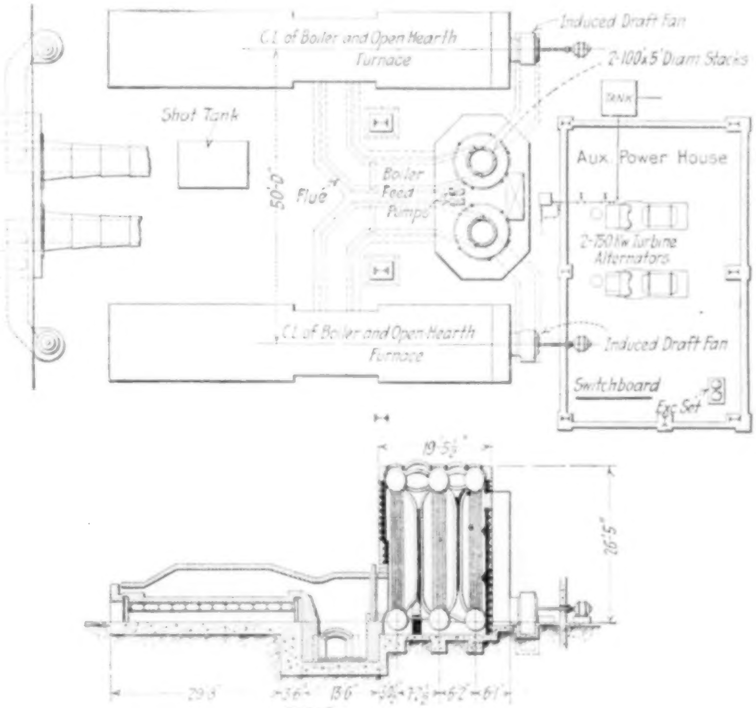

Fig. 3 Plan and Elevation Showing Arrangement of Open-Hearth Furnaces with Waste-Heat Boilers and Auxiliary Power Plant

safety cylinder covers are used with these hammers, also special guides and shoes.

The two smaller hammers follow the same general lines except they are of the two-leg type and in some parts cast iron replaces steel. Special shapes are forged on these hammers, in addition to the usual forged work.

The Rolling Mills

The mills consist of two departments:

a Merchant and wire-rod mills for the production of sheet bars, billets, rods of various sizes and shapes, and wire rod in coils

b A sheet mill for the production of hot- and cold-rolled sheets.

On account of the extremely tough character of monel metal and the tendency it has of cooling rapidly, it is necessary to have mills of great strength and rigidity. The type of material rolled is similar to alloy tool steel and it is very necessary to have mills with machine work and general finish the best of its kind and that are equipped with fittings that require a minimum of adjustment.

The hammered ingot or bloom after being overhauled to remove any scale or surface imperfections is delivered to the 24-in. sheet-bar mill, located in the merchant-mill building, Fig. 4. This mill consists of two stands, the first stand three-high and the bull head, or finishing stand, two-high.

The handling of blooms to the heating furnaces and thence to the standard mill tables is by means of a Brosius charger. The tilt-

ing tables, 25 ft. long, the transfer, and other table operations are controlled from the same pulpit. After being rolled the bar is carried to an exceptionally heavy shear with a capacity to cut $3^1/_2$-in. by 12-in. billets.

The Sheet Mills

The general arrangement of the sheet mills is shown in Fig. 5. The mills themselves are exceptionally heavy, the roll diameters

by a motor drive, a 40-hp. motor being used which is carried on the top of the pinion housing. The main motor to drive this mill is a 1200-hp. motor, which is geared with a double-reduction gear giving a total reduction of 13 to 1 and a mill speed of 26 r.p.m. Two 10-ton flywheels are used, running at the motor speed approximately 10,000 ft. per min.

The furnaces are of the wide-door type, being double sheet furnaces and four-door pair furnaces. The air at 16 oz. is furnished

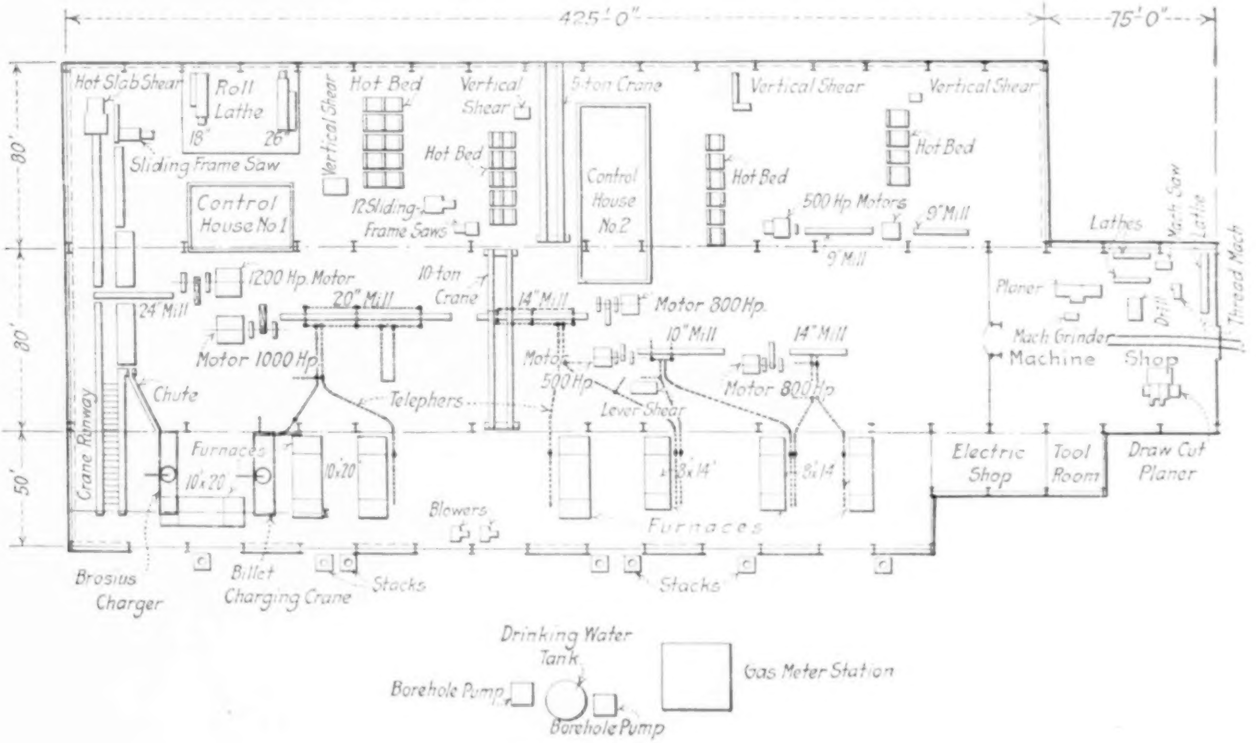

FIG. 4 GENERAL PLAN OF MERCHANT MILL

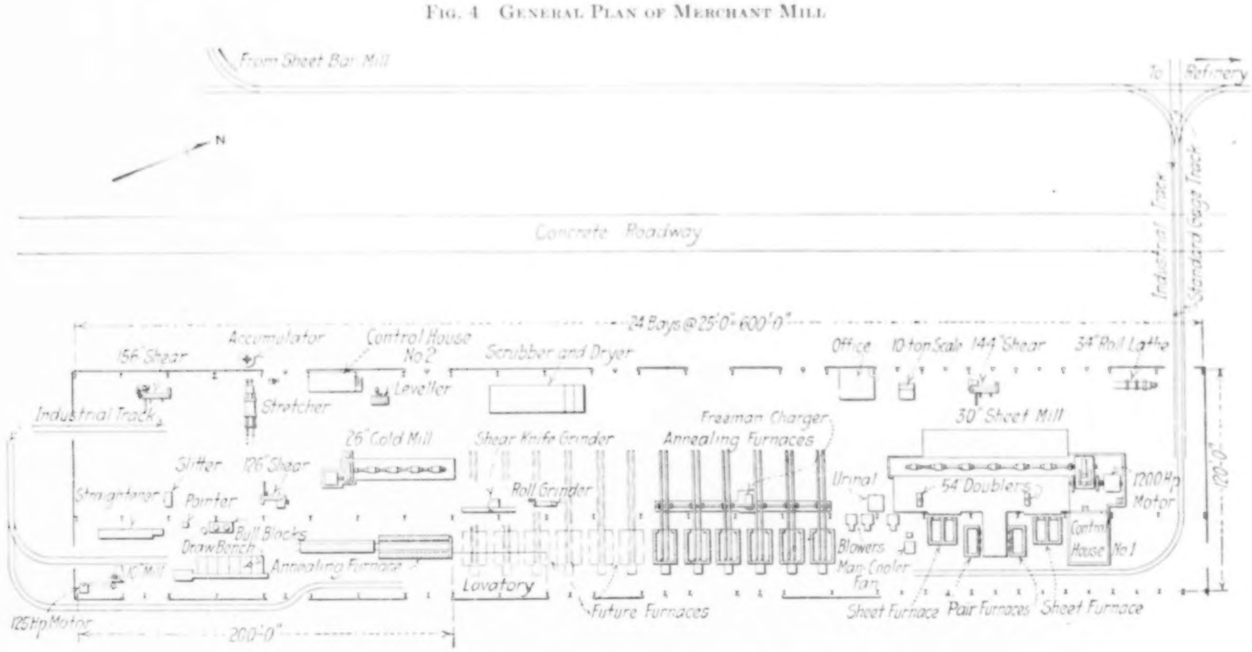

FIG. 5 GENERAL PLAN OF SHEET MILL

being 30 in. and the maximum sheet width 48 in. The present complement consists of two finishing mills and two roughing mills, each finishing mill having a roughing mill of its own. The roughing rolls are balanced and are driven by fully enclosed cut gears, a rather new development in sheet-mill practice, giving a very smooth movement and reducing the tendency of the pinion teeth to mark the sheet. A specially designed drag, known as the "Conklin" drag, is furnished. The roughing rolls are screwed up and down

by three blowers, of 4000 cu. ft. per min. capacity, which also furnish the air for the six annealing furnaces. Natural gas is used in all furnaces. The annealing furnaces are equipped with Freeman-type charging machines. The crane capacity over this mill is 30 tons with a 25 per cent overload and a 10-ton auxiliary.

The 26-in. cold-roll mill at the south end of the building consists of four stands of cold rolls driven by a 300-hp. motor. Construction

(Continued on page 331)

High-Temperature and High-Pressure Steam Lines

By B. N. Broido,[1] New York, N. Y.

The pronounced tendency of modern power-plant designers to use high superheat and high pressure, as well as the recent extensive use of highly superheated steam in process work, lead the author to make a review of the available data and formulas on radiation and friction losses in pipe lines. All tests to determine the radiation losses of pipe lines carrying high-temperature steam made in this country have been practically exclusively with electrically heated pipes. This paper gives results and an analysis of tests made with superheated steam flowing through a pipe line. The heat-transmission coefficients of bare and covered pipes at various steam velocities, superheats, and pressures are given. Suggestions are made regarding the steam velocities to be selected in order to transmit steam more economically.

The formulas available at present for figuring the friction losses of steam in pipe lines are limited to the range for which they were established, or for comparatively low pressures. Corrections of these formulas are shown in this paper, based on observations of a pipe line carrying high-pressure steam, which corrections may be used by designers of high-pressure power plants in dimensioning their pipe mains.

The paper further treats of pipe lines carrying superheated steam for other purposes than power. Recommendations as to the velocities or pipe sizes to be chosen are given, as well as a few examples from practice to show how the velocities selected were advantageously applied.

The use of superheated steam in power plants, as well as for various kinds of process work, has become so extensive during recent years that it is hardly necessary to enlarge on its advantages. The fuel saving effected by the use of superheated steam, the lower maintenance cost of turbines using it, and the numerous advantages it has in various kinds of process work are some of the factors which have helped to assign to it the important position it now occupies in the opinion of technical men.

One of the phases in which engineers, power-plant operators, and managers are naturally interested in this connection is that of conducting superheated steam through pipe lines. Very little, however, has been published in this country on the subject.

The recent tendency in designing power plants, particularly those of large size, is toward high pressures. The high temperatures and high pressures involve new problems, among others being that of proportioning the pipe lines. A study of the losses of heat and pressure in pipe lines carrying highly superheated and high-pressure steam at the present opportune time will aid the designer in dimensioning the steam lines.

The field is very large, and this paper will therefore be confined to the discussion of—

a Radiation losses in pipe lines carrying superheated steam

b Resistance to the flow or pressure drop of superheated steam in pipe lines

c The most advantageous steam velocity, particularly for high-pressure lines; and

d Other features to be taken in consideration in designing pipe lines for transmission of superheated steam of either low or high pressures.

Radiation Losses in Pipe Lines Carrying Superheated Steam

Up to the present the usual method of determining radiation losses has consisted in supplying saturated steam to a pipe either naked or covered with a definite thickness of lagging, and weighing the amount of steam condensed. Such experiments, however, are mostly inaccurate, due to the fact that no separator completely removes the moisture from the steam, and also because of the difficulties in completely draining the tested pipe. So far as the author is aware, no experiments with superheated steam in pipe lines have been made in this country.

The author has had the opportunity to study this subject and to examine the results of tests conducted in Europe in which both saturated and superheated steam were used, particularly the tests made by Dr. Bernard and Herr Eberle of Magdeburg and Munich, respectively.[1] Table 1 shows the results of tests with saturated steam in bare pipes of approximately 3 in. and 6 in. internal diameter. The surfaces given in the table include the surface of the flanges. It is of interest to note that while the temperature of the pipe wall was very near to that of the steam, the temperature of the flanges was slightly lower. The difference in some cases is as high as 30 deg. fahr.

The tests were also conducted with different types of insulation, the results, however, being similar to those obtained in like tests in this country.

Tests to determine the heat loss by transmission of superheated steam can be carried out only with steam that is flowing. The heat content of steam, both at the inlet and outlet of the pipe, must be determined, and the difference multiplied by the amount of steam flowing through the pipe gives the heat loss. Superheated steam flowing through a pipe may change its heat content—

a By decreasing its temperature

b By pressure drop

c By partial condensation.

The accurate measurement of any condensed water would be impossible, due to the fact already mentioned that separators are not reliable. To be accurate, tests with superheated steam must therefore be conducted with sufficiently high temperatures so that the temperature of the pipe wall at the outlet does not descend below that of saturated steam at the same pressure.

TABLE 1 HEAT LOSS FROM 3-IN. AND 6-IN. BARE PIPES—SATURATED STEAM

Pipe Line			Pressure abs., lb. per sq. in.	Steam temp., deg. fahr.	Air temp., deg. fahr.	Temp. diff. betw. steam air, deg. fahr.	Condensed water for 1 ft. length, lb. per hr.	Heat Loss	
Length, ft.	Inside diam., in.	No. Flanges						Per sq. ft. surface per hr., B.t.u.	Per sq. ft. per deg. temp. diff. per hr., B.t.u.
			46.60	274.46	60.98	213.48	0.5174	575.7	2.672
			46.01	273.56	59.54	214.02	0.5168	575.3	2.672
			46.45	274.10	61.88	212.22	0.5114	570.2	2.672
			96.43	322.52	65.66	256.86	0.6948	744.0	2.876
87.25	2.76	6	96.87	322.88	62.96	259.92	0.7063	755.9	2.876
			95.84	322.16	70.34	251.82	0.6982	758.5	2.958
			190.22	374.72	76.10	298.62	0.9092	932.4	3.100
			191.69	375.26	71.06	304.20	0.9415	964.7	3.142
			47.78	275.9	72.50	203.40	1.0362	545.4	2.672
			48.95	277.34	78.26	199.08	1.0087	537.2	2.652
			99.23	324.68	89.06	235.62	1.3628	689.3	2.897
85.28	5.91	7	98.78	324.32	86.36	237.96	1.3803	698.9	2.917
			192.13	375.44	87.08	288.36	1.9320	935.7	3.223
			191.98	375.44	95.75	279.69	1.8715	906.9	3.223

Knowledge of the wall temperature was considered important, not only to determine the minimum superheat required to eliminate condensation, but also to determine the coefficient of heat transfer from superheated steam to a pipe wall.

In view of the fact that the velocity of superheated steam doubtless has an influence upon the heat transmission, tests were conducted with different velocities. The results of tests conducted with bare pipes were highly impressive. At a velocity of about 100 ft. per sec. and steam temperatures of 291 to 390 deg. cent. (556 to 734 deg. fahr., corresponding to 221 and 399 deg. super-

[1] Consulting engineer, The Superheater Company. Mem. A.S.M.E.

Contributed by the Power Division and presented at the Annual Meeting, New York, December 4 to 7, 1922, of The American Society of Mechanical Engineers. Abridged. All papers are subject to revision.

[1] Mitteilungen über Forschungsarbeiten (Berlin), V. D. I., Hefte 21 and 78.

TABLE 2 COEFFICIENTS OF HEAT-TRANSMISSION FOR BARE AND COVERED PIPES AT VARIOUS STEAM TEMPERATURES AND SAVINGS RESULTING FROM COVERING PIPE—SUPERHEATED STEAM

Final steam temp., deg. fahr.	3-in. Line			6-in. Line		
	K		Saving through covering, per cent	K		Saving through covering, per cent
	Bare pipe, B.t.u.	Covered pipe, B.t.u.		Bare pipe, B.t.u.	Covered pipe, B.t.u.	
212	2.4	0.47	80.4	2.32	0.381	83.6
230	2.48	0.47	81.1	2.42	0.383	84.2
248	2.57	0.47	81.7	2.52	0.385	84.7
266	2.64	0.47	82.3	2.62	0.387	85.3
384	2.73	0.47	82.8	2.72	0.389	85.7
302	2.81	0.47	83.4	2.81	0.391	86.1
320	2.89	0.47	83.8	2.91	0.393	86.5
338	2.98	0.47	84.2	3.01	0.395	86.9
356	3.06	0.47	84.6	3.1	0.397	87.2
374	3.14	0.47	85.0	3.2	0.399	87.5
392	3.22	0.47*	85.4	3.3	0.401	87.9

TABLE 3 VARIATION OF HEAT LOSSES, HEAT-TRANSMISSION COEFFICIENTS FOR BARE AND COVERED PIPES AND SAVINGS RESULTING FROM COVERING PIPE, WITH TEMPERATURE DIFFERENCE BETWEEN STEAM AND AIR —SUPERHEATED STEAM

Temperature difference between steam and air, deg. fahr.	Heat loss per square foot of outside pipe surface per hour		Saving through the covering, per cent	K	
	Bare pipe, B.t.u.	Covered pipe, B.t.u.		Bare pipe, B.t.u.	Covered pipe, B.t.u.
212	453	78.5	82.7	2.50	0.43
257	606	103.2	83.0	2.67	0.45
302	773	130.2	83.2	2.83	0.48
347	971	160.5	83.5	3.06	0.51
392	1184	192.4	83.7	3.26	0.53
437	1394	225.2	83.8	3.43	0.55
482	1637	260.8	84.1	3.63	0.57
527	1909	303.4	84.1	3.83	0.60
572	2192	344.1	84.3	4.04	0.63
617	2497	384.8	84.6	4.22	0.65
662	2804	429.2	84.7	4.43	0.67
707	3135	478.7	84.7	4.61	0.70
752	3149	529.8	84.8	4.81	0.73

heat), the temperature difference between the steam and pipe wall was 34 deg. cent., while α_1 the heat-transmission coefficient was 35. With steam velocities of 33 ft. per sec. the difference between the steam and the pipe-wall temperatures was greater. At the lower steam temperatures of 220 to 267 deg. cent. (428 to 513 deg. fahr.) the temperature difference was 45 to 65 deg. cent. (86 to 122 deg. fahr.) and the heat-transmission coefficient α_1 was 16. By decreasing the velocity of the steam one-third, the coefficient of heat transmission between superheated steam and the pipe wall was decreased to one-half of the first value. This indicates clearly that the behavior of superheated steam is different from that of saturated steam as far as imparting heat to a metallic wall is concerned, which is due to the fact that saturated steam, in transferring heat to the pipe wall, partly condenses or gives up some of its latent heat, which heat is not as closely combined with the steam as the sensible heat of a liquid or the heat of superheat. This fact often is not understood, even by technical men.

While the results of the tests with bare pipe—particularly the variation of the heat-transmission coefficient at different temperatures and velocities—are not important in connection with pipe lines which invariably are insulated, they are of considerable interest as far as the use of superheated steam for heating and drying purposes is concerned.

The experiments demonstrate that the heat-transmission coefficient increases considerably with the increased velocity, and also that the wall temperature depends not only upon the steam temperature but also upon its velocity.

Table 3 gives the results obtained with superheated steam in covered pipes. The same covering was used as for the test with saturated steam. A comparison of the values of Tables 2 and 3 for saturated and superheated steam in covered pipes brings out the fact that for the steam-temperature range from 100 to 200 deg. cent. (212 to 392 deg. fahr.), with either saturated or superheated steam, the heat-transmission coefficient K remains practically the same. With increased temperatures this coefficient shows a tendency to rise considerably. For temperatures from 100 to 200 deg. cent. (212 to 392 deg. fahr.), K for lines with pipes and flanges covered is about 0.47. It increases, however, with the steam temperature, up to 0.69 at 400 deg. cent. (752 deg. fahr.).

While from the tests one would conclude that the direct radiation losses for superheated steam are not appreciably lower than those of saturated steam of the same temperature, there are, however, a few other points to be considered in estimating the relative advantages of the two so far as their transmission through pipe lines is concerned. With saturated steam any heat radiated causes a part of the steam to be condensed, and the condensate, particularly for long pipe lines, is not returned to the boiler but is discharged through traps and wasted, so that in addition to the direct heat lost by radiation there is a further loss of the liquid heat of the condensate, which in some cases, particularly for high-pressure steam, may amount to 25 per cent of the radiated heat. With superheated steam the heat lost only decreases the temperature and no condensation occurs as long as the steam remains superheated so that no additional heat besides that radiated is wasted.

Another important fact to be considered in connection with superheated steam is that a considerably higher velocity in the pipe lines is permissible. The velocity of the steam in a pipe, or the size of the pipe, is usually determined by the maximum friction loss or pressure drop which can be allowed.

Due to the low pressure drop and high velocity possible with superheated steam a greater amount of steam can be transmitted with the same pipe, so that the radiation losses per unit weight are less. Therefore, in order to make a fair comparison between the radiation losses in carrying superheated and saturated steam, not the direct heat should be considered, but the total heat losses in percentage of the heat conveyed in the steam through the pipe. Table 4 gives the heat losses in pipe lines from 4 to 12 in. in diameter for saturated steam and for steam superheated 100, 150, and 200 deg., at gage pressures of 100, 150, and 200 lb. The values are calculated using the heat-transmission coefficients as given in Tables 2 and 3, and the values for saturated steam include the liquid heat of the condensed steam.

Pressure Drop of Superheated Steam in Pipe Lines

The question of friction loss in pipe lines carrying gases or vapors has been studied by many authorities, and a number of formulas have been established which differ considerably. The author has had the opportunity of making observations on the friction loss in long pipes with both superheated and saturated steam, and after a considerable study of the subject, has come to the conclusion that, particularly for long pipe lines and moderate pressures, the formula—

$$P = \frac{CW^2L\left(1 + \dfrac{3.6}{d}\right)}{Vd^5}$$

which varies with the diameter of the pipe—using the coefficient 0.0001321 suggested by Babcock—is approximately correct for smaller pipe lines up to 4 in. in diameter; while for larger pipes, especially with wet steam, the formula $P = CW^2L/Vd^5$, with the coefficient suggested by Martin, Hawksley or Gutermuth, varying from 0.0003135 to 0.0003557 and depending upon the wetness of the steam and the surface of the pipe, is more likely to be correct.

For superheated steam with low temperatures and low velocities so that the wall temperature is lower than that of saturated steam and the walls are therefore covered inside with a film of water, the pressure drop is approximately the same as that of dry saturated

steam. With higher temperatures, higher velocities and correspondingly higher wall temperatures so that the pipe remains dry inside, the coefficient C for superheated steam varies not only with the diameter of the pipe but also with the velocity, the pressure, the absolute temperature, and the density; and the friction loss agrees closely with that observed by Fritsche,[1] so that his suggested formula for the coefficient C which follows can be considered reliable and used safely in calculating the pressure drop for long pipe lines carrying superheated steam and moderate pressures:

$$C = 0.0000022\ (R/144)^{0.148}\ (T/pw)^{0.148} d^{-0.269}$$

where—

T = absolute temperature, deg. fahr.
p = absolute pressure, lb. per sq. in.
w = velocity, ft. per sec.
d = pipe diameter, ft.
R = 85.7 for steam.

In order to facilitate the use of this formula a table was calculated giving for air (R = 53.34) the values of 1,000,000 C corresponding to values of the ratio T/pw for pipe diameters ranging from 1 in. to 48 in. This table is given in Marks' Mechanical Engineers' Handbook. When used for steam its values must be increased by 7 per cent on account of the different value of R used.

TABLE 4 COMPARISON OF CAPACITY, RADIATION LOSS AND PRESSURE DROP OF PIPE LINES TRANSMITTING SATURATED AND SUPERHEATED STEAM

Saturated Steam								Superheated Steam								
Press. abs., lb. per sq. in.	Press. drop, lb. per sq. in.	Velocity ft. per min.	Wt. of steam, lb. per hr.	Million B.t.u. trans. per hr.	Rad. loss	Total loss	Per Cent loss	Press. abs., lb. per sq. in.	Deg. super-heat	Press. drop, lb. per sq. in.	Velocity, ft. per min.	Wt. of steam, lb. per hr.	Million B.t.u. trans. per hr.	Rad. loss	Per cent loss	Per cent saving
4-In. Pipe (Extra Strong Above 125 Lb. Pressure)																
115	0.54	3000	4,080	4.12	16,060	19,400	0.47	115	100	1.24	6,000	7,020	7.46	26,400	0.34	27.7
									150	1.18	6,000	6,575	7.15	28,800	0.40	14.9
									200	1.12	6,000	6,225	6.92	33,200	0.48	......
165	0.79	3000	5,170	5.25	17,650	22,180	0.42	165	100	1.75	6,000	8,975	9.65	26,850	0.28	33.3
									150	1.67	6,000	8,400	9.22	31,200	0.34	19.01
									200	1.58	6,000	7,910	8.90	35,800	0.40	4.76
215	1.03	3000	6,560	6.67	18,900	24,375	0.37	215	100	2.17	6,000	11,480	12.40	28,800	0.23	37.9
									150	2.04	6,000	10,750	11.78	33,400	0.28	24.3
									200	1.94	6,000	10,135	11.20	38,600	0.34	8.1
6-In Pipe (Extra Strong Above 125 Lb. Pressure)																
115	0.36	3000	9,660	9.75	23,650	28,780	0.29	115	100	0.75	6,000	16,000	17.66	37,400	0.21	27.6
									150	0.71	6,000	15,550	16.92	42,450	0.25	13.8
									200	0.67	6,000	14,710	16.35	49,000	0.30	......
165	0.55	3000	10,520	10.78	26,000	32,670	0.30	165	100	1.04	6,000	20,280	21.80	39,400	0.18	40.0
									150	0.99	6,000	19,000	20.85	46,000	0.22	26.7
									200	0.94	6,000	17,900	20.15	52,650	0.26	13.3
215	0.72	3000	13,500	13.75	27,900	36,000	0.26	215	100	1.29	6,000	25,950	28.00	42,400	0.15	42.35
									150	1.22	6,000	24,320	26.85	48,900	0.18	30.8
									200	1.16	6,000	22,950	25.90	56,700	0.22	15.4
8-In. Pipe (Extra Strong Above 125 Lb. Pressure)																
115	0.37	3500	18,820	19.0	31,800	39,500	0.21	115	100	0.71	7,000	32,410	34.5	48,600	0.14	33.3
									150	0.67	7,000	30,390	33.1	55,100	0.17	19.05
									200	0.64	7,000	28,710	31.85	63,700	0.20	4.76
165	0.54	3500	24,200	24.55	33,900	42,600	0.17	165	100	0.99	7,000	41,470	44.45	51,380	0.12	29.4
									150	0.94	7,000	38,810	42.6	59,770	0.14	15.62
									200	0.89	7,000	36,580	41.08	68,610	0.17	......
215	0.70	3500	31,150	31.7	36,300	46,800	0.15	215	100	1.23	7,000	53,040	57.23	55,130	0.10	33.3
									150	1.16	7,000	49,680	54.90	63,740	0.12	20.0
									200	1.10	7,000	46,880	52.97	73,980	0.14	6.67
10-In. Pipe (Extra Strong Above 125 Lb. Pressure)																
115	0.38	4000	33,850	34.15	38,410	46,750	0.14	115	100	0.69	8,000	58,200	61.87	60,760	0.10	28.5
									150	0.65	8,000	54,500	59.30	68,900	0.12	14.25
									200	0.63	8,000	51,500	57.16	79,530	0.14	......
165	0.56	4000	45,200	45.88	42,280	53,130	0.12	165	100	0.95	8,000	77,500	83.10	63,670	0.08	33.3
									150	0.91	8,000	72,500	79.60	74,580	0.09	25.0
									200	0.86	8,000	68,400	76.80	85,620	0.10	6.65
215	0.72	4000	58,200	59.30	45,320	58,460	0.10	215	100	1.19	8,000	99,100	106.9	68,800	0.06	40.0
									150	1.13	8,000	92,800	102.5	79,530	0.08	20.0
									200	1.07	8,000	87,600	98.9	92,320	0.09	10.0
12-In. Pipe (Extra Strong Above 125 Lb. Pressure)																
115	0.50	5000	60,720	61.27	45,570	55,470	0.09	115	100	0.87	10,000	104,200	110.8	72,070	0.07	22.3
									150	0.82	10,000	97,800	106.4	81,600	0.08	11.12
									200	0.78	10,000	92,500	101.8	94,340	0.09	......
165	0.72	5000	82,170	83.4	50,100	62,950	0.08	165	100	1.18	10,000	140,900	151.0	76,050	0.05	37.5
									150	1.11	10,000	131,900	144.8	88,470	0.06	25.0
									200	1.06	10,000	124,100	139.4	101,560	0.07	12.5
215	0.93	5000	105,800	107.8	53,650	69,220	0.07	215	100	1.45	10,000	180,100	194.3	81,600	0.04	42.8
									150	1.38	10,000	168,950	186.7	94,340	0.05	28.6
									200	1.32	10,000	159,150	179.8	109,500	0.06	14.29

[1] Mitteilungen über Forschungsarbeiten, V. D. I. (Berlin), Heft 60.

As far as the author knows, all formulas for determining pressure drop, particularly for steam, are based on tests where the pressures in no case exceeded 300 lb. per sq. in. For higher pressures they should be used with caution. In his extensive study of this subject and search for a formula which would cover all conditions, Biel[1] found that the pressure drop caused by the resistance to flow of any fluid, for the same diameter of pipe, the same length, same temperature, and the same constant R, can be expressed by the equation $P_d = CW^n p^m$, in which the values of the exponents are $n = 1.852$, $m = 0.852$. Approximately the same values were found by Brabbée,[2] who made extensive tests, particularly to determine the resistance, in pipe lines, for high- and low-pressure steam and hot-air heating. He found, however, that the exponents vary with the roughness of the pipe. For steel pipe his exponent is 0.853.

The question arises as to how far the known formulas for the resistance of flow are applicable to high-pressure and high-temperature steam. It is the opinion of the author that the pressure drop in *straight lines* carrying superheated steam of 300 to 600 lb. pressure is from 10 per cent to 25 per cent less than that calculated by the use of the existing formulas for moderate pressures.

A comparison of the results of tests made at pressures between 250 and 440 lb. with those obtained by using the Fritsche formula bears out this statement. The pressure drop in fittings and bends was carefully determined by mercury U-tubes, and the resistance to the flow, which is usually expressed in lengths of straight pipe, was considerably higher than formerly supposed. As compared with the formula of Conrad Meier, given in the paper of D. E. Foster,[3] the values obtained were from 20 per cent to 35 per cent higher.

The foregoing would tend to show that most of the pressure drop in pipe lines takes place in the bends, fittings, and valves, especially the latter, rather than in the straight pipes. In particular, sudden restriction of area and change in direction of flow affect the pressure of the steam. This has been verified by careful tests even with moderate pressures.

TABLE 5 VALUES OF 1,000,000 C

Diameter in inches	Values of the ratio T/Pw						
	0.008	0.01	0.015	0.02	0.03	0.04	0.05
4	1.35	1.38	1.43	1.46	1.53	1.60	1.65
5	1.23	1.29	1.33	1.37	1.44	1.50	1.55
6	1.16	1.21	1.26	1.30	1.37	1.43	1.48
8	1.10	1.14	1.18	1.22	1.27	1.33	1.37
10	1.03	1.07	1.11	1.14	1.19	1.25	1.29
12	1.00	1.03	1.07	1.10	1.14	1.19	1.23

TABLE 6 PRESSURE DROP AND RADIATION LOSSES IN PIPE LINES CARRYING HIGH-PRESSURE SUPERHEATED STEAM

Pressure Abs. lb.	Deg. Super Heat	Pressure Drop	Velocity ft. per min.	Wt. Steam lb. per hr.	Million B.t.u. trans per hr.	Rad. loss	Pressure abs. lb.	Deg. Super heat	Pressure drop	Velocity ft. per min.	Wt. Steam lb. per hr.	Million B.t.u. trans per hr.	Rad. loss
4-in. Pipe (Extra Strong)													
315	100	2.60	6000	16450	17.92	32100	415	100	3.03	6000	21190	23.25	34750
	150	2.46	6000	15400	17.18	37150		150	2.84	6000	19740	22.20	39550
	200	2.34	6000	14470	16.50	42200		200	2.68	6000	18460	21.20	45250
6-in. Pipe (Extra Strong)													
315	100	1.58	6000	37300	40.60	47300	415	100	1.79	6000	47900	52.60	51350
	150	1.48	6000	34900	38.90	54750		150	1.68	6000	44600	50.20	58400
	200	1.39	6000	32700	37.40	62000		200	1.59	6000	41750	48.00	66900
8-in. Pipe (Extra Strong)													
315	100	1.44	7000	76000	82.80	60600	415	100	1.68	7000	97900	107.3	65750
	150	1.36	7000	71200	79.50	70200		150	1.57	7000	91250	102.6	75000
	200	1.29	7000	66900	76.40	79700		200	1.49	7000	85400	98.2	80000
10-in. Pipe (Extra Strong)													
315	100	1.37	8000	142100	154.8	76800	415	100	1.57	8000	183000	205.0	83250
	150	1.29	8000	133000	148.2	88700		150	1.48	8000	170400	192.0	94000
	200	1.22	8000	125000	142.7	100900		200	1.4	8000	159500	183.6	108700
12-in. Pipe (Extra Strong)													
315	100	1.65	10000	258500	282.0	91300	415	100	2.04	10000	332500	365.0	[illegible]
	150	1.56	10000	242000	270.0	105200		150	1.90	10000	309500	348.0	112700
	200	1.47	10000	227000	259.0	119800		200	1.79	10000	290000	334.0	129200

Best Velocity of Steam Flow for Use in High-Pressure Lines

It is therefore apparent that in pipe lines carrying high-pressure steam, provided they consist of long, straight pipe sections, high velocities are permissible, and for high pressures—say, from 300 to 500 lb.—10,000 to 12,000 ft. per min. seems to be the most advisable for lines over 5 in. in diameter and with a continuous steam flow, as, for instance, when the steam is used in turbines. With reciprocating engines, naturally, lower velocities are to be chosen, depending upon the length of the line, the percentage of cut-off, and the number of revolutions of the engine. For high-pressure reciprocating engines located at a considerable distance from the steam generator it was found advisable to make that portion of the steam line near the engine of a larger diameter in order to minimize the fluctuation of the steam flow due to the intermittent steam demands of the engine, and to allow higher velocities by means of a correspondingly smaller pipe diameter, near the boiler.

If a line carrying high-pressure steam contains a number of bends, fittings, and valves, lower velocities than those mentioned in the preceding paragraph should be employed if excessive pressure drop is to be avoided.

The higher cost of the larger sizes necessitated by lower velocities, and the strength of the material required for higher pressures, are factors to be taken in consideration in determining the size of the line.

The table previously mentioned giving values of 1,000,000 C is intended only for low pressures. Table 5 has therefore been devised to give values of the same quantity for pressures up to 600 lb. and any superheat. Table 6 gives the pressure drop and radiation losses for pipes from 8 to 12 in. in diameter and for 300 to 400 lb. pressure.

Pipe Lines Carrying Superheated Steam for Other Purposes Than Power Generation

The question of friction losses or pressure drop in a pipe line, particularly with superheated steam, is of importance only when the steam is used for generation of power. If it is used for heating, drying, or process work, only its temperature need be considered, the pressure being of no consequence. Higher velocities can therefore be chosen. Very often the pressure has to be reduced before the steam be used, and a pressure drop in the pipe line is even desirable. With saturated steam, however, it is necessary to limit the velocity. The usual velocities with saturated steam in commercial pipe lines are about 3000 to 6000 ft. per min. Any considerably higher velocity increases the danger of water hammer, particularly in long lines with a number of bends, fittings, and changes in diameter, and when the line cannot be completely and continuously drained. In such lines high velocities with saturated steam cause considerable vibration, especially when *much* moisture is carried with the steam, due to the effect at higher velocities of the greater weight of water at any change in direction of the flow.

With superheated steam, particularly at sufficiently high temperatures, practically no moisture is present in the line, and nothing prevents the use of the highest speeds desired. Velocities of

[1] Mitteilungen über Forschungsarbeiten, Heft 44.

[2] Zeitschrift des Vereines deutscher Ingenieure, 1916.

[3] Effect of Fittings on Flow of Fluids through Pipe Lines, Trans. A.S.M.E., vol. 42, p. 647.

12,000 to 15,000 (and more) ft. per min. can be and have been applied in larger pipe lines without any undesirable effects. In figuring the total radiation losses in Table 4, velocities of 3000 to 5000 ft. per min. were assumed for saturated steam, and 6000 to 10,000 ft. for superheated steam, which are conservative values that enable a fair comparison to be made.

Table 4 shows that the greatest saving, as far as radiation losses are concerned, is obtained with 150 deg. superheat, so that when the steam is superheated only for the purpose of elimination of condensation or reduction of radiation, a moderate superheat of 100 to 150 deg., depending upon the length of the line, is sufficient. It does not mean, however, that moderate superheat is in general more desirable. If the steam is used for power purposes, the advantages of high superheat in the prime mover will more than overbalance the slightly higher radiation losses.

A remarkable feature is the very slight increase of pressure drop, which throughout the whole range of the table, with one exception, does not exceed 1 lb. for 100 ft. of pipe length, in spite of the fact that the velocity was doubled. The lower density of superheated steam, the absence of mositure, the dry pipe walls, and the reduced amount of foreign matter—the greatest part of which is usually left in the superheater—account for the low pressure drop.

It is commonly believed that even with superheated steam the pipe walls are covered on the inside with a film of moisture. This is true for low superheat with low steam velocities. At higher superheat and high velocities, however, the wall attains a temperature higher than that of saturated steam, and remains dry.

Examples Showing Advantages of Using Higher Velocities with Superheated Steam

The three following examples from actual practice demonstrate how the possibility of applying higher velocities with superheated steam may be advantageously utilized in reducing the radiation losses and the cost of the piping and covering.

The management of a large textile concern, realizing that it was necessary to lower their power cost, decided as one means to this end to avail themselves of the advantages of superheated steam. Each of the five boilers in the plant was accordingly equipped with superheaters for 200 deg. superheat.

The steam was for use in two engines, one triple-expansion and one compound. The compound engine was located about 950 ft. from the boiler house. The piping between boiler and engine was entirely changed, the old 8-in. piping, being replaced by a new 6-in. line. With the old piping and saturated steam the average pressure drop in the line between boiler and engine was 6 lb. With the new line and superheated steam it was 7.5 lb. The comparatively low pressure drop in the new line was mainly due to the appreciably decreased steam consumption of the engine. The radiation loss of the 8-in. line would naturally be 33 per cent higher than that of the 6-in. line for the same steam temperature.

A chemical company manufacturing aniline dyes had an 8-in. pipe line, 1400 ft. long, in their plant, conveying steam from their boiler room to the process house. An increase in production required the approximate doubling of the steam consumption in the power house, and a second pipe line accordingly was planned. At the same time the use of higher temperatures was found advisable, since the boiler pressure could not be increased appreciably. Superheaters were installed in the boilers, and approximately double the amount of steam superheated was sent through the pipe. Pressure drop was of no consequence, while the radiation loss per pound of steam conveyed was decreased 36 per cent.

A heating plant had two mains 10 in. and 8 in. in diameter and 2300 ft. long. The 10-in. line was used in the cold winter months, while the smaller one was utilized during the remainder of the year. With saturated steam the larger steam demand in the winter months could not be supplied with the small pipe alone, due to the danger of water hammer and excessive vibration, and the larger pipe had to be used. In order to have dry steam at the end of the line, and avoid the losses in liquid heat of the steam condensed in the line, superheaters were installed, and it was found that the greater amount of steam could be conveyed through the smaller pipe without any difficulty. The radiation loss as compared with the 10-in. line was 20 per cent less.

Discussion[1]

Geo. A. Orrok[2] said that the author had once more emphasized that if the outside surface was kept low, and arranged so that it radiated but little, the pipe-line losses would be small. He had covered the velocity of steam in pipes up to 10,000 ft. per min. This was a very ordinary velocity for power plants; in most cases the velocities were greater. It should always be borne in mind that losses were proportional to the surface and not to the amount of steam in the pipe.

J. A. Barnes[3] wrote calling attention to a power plant at Conneaut, Ohio, operating with saturated steam through a pipe line between 400 and 600 ft. long. At this distance it was impossible to operate the engine at anything like its full capacity. Superheaters were installed and about 100 deg. of superheat was obtained at the engine, and the capacity was materially increased. At the Bellman-Brook Co., a finishing company in Fairview, N. J., superheaters were installed which gave from 100 to 150 deg. of superheat, and the output of the plant was increased approximately 35 per cent due entirely to the elimination of radiation losses.

W. H. Armacost[4] said that he had plotted some comparative curves, taking the data from papers presented before the Society by Messrs. McMillan, Bagley, Heilman, and the author. The curve plotted from the data of Mr. Broido's Table 3 bore out his statement that there was less radiation by using superheated steam in pipe lines than with saturated steam, due to the fact that saturated steam, in transferring heat to the pipe wall, partly condensed or gave up some of its latent heat, which heat was not as closely combined with the steam as the sensible heat of a liquid or the heat of superheated steam.

J. H. Lawrence[5] stated that in designing the Hell Gate station, probably the largest in the country, the losses in the steam line had been compared with the losses estimated by various formulas, and while there should have been a very excessive drop in the lines, the loss was only about half that given by any formula in the handbooks, and so small that it was almost negligible.

He did not believe in low velocities. The author mentioned 10,000 ft., but he considered this too low for most steam pipes in a large station. His concern used as a maximum 15,000, and in certain cases, where the lines would only be used in case of an emergency, they did not hesitate to go to 20,000 ft. per min. In most handbooks there were certain rules about velocity which provided for 6000 or 8000 ft. for saturated steam and 10,000 for superheated steam. Such information was very misleading.

Their experience has shown that the velocity should increase as the size of the pipe increased. For one particular case, if a 2-in. pipe was used, the velocity would be around 2000 ft. per min., otherwise the losses would be very excessive. With a 6-in. pipe the proper velocity would be about 6000 ft., and so on. On the 14-in. size they figured about 14,000 ft. velocity as the minimum. They had stopped there, however, as they did not wish to go as high as 20,000 ft. in ordinary practice.

E. G. Bailey[6] said that the steam meter had now become such an integral part of the plant equipment for measuring the output of boilers, steam consumption of turbines and various units as well as the steam distribution, that the conditions suitable for the installation of such meters should be considered not only in the selection of the proper size of pipe but also in the layout.

One meter manufacturer used limiting velocities of $V_{max} = 8000\sqrt{\text{sp. vol.}}$ and another $V_{max} = 10{,}500\sqrt{\text{sp. vol.}}$ With steam at 250 lb. pressure and 200 deg. fahr. superheat having a specific volume of 2.35 the maximum velocities would be 12,240 and 16,000 ft. per minute, respectively. These velocities were capable of being metered accurately only when the steam was flowing through straight pipe of reasonable length on either side of the primary device.

L. B. McMillan[7] stated that it was a matter of common knowledge

[1] These extracts from the discussion deal with those portions of the paper appearing in the preceding abridgment.
[2] Cons. Engr., 17 Battery Place, New York, N. Y. Mem. A.S.M.E.
[3] Superheater Co., New York, N. Y.
[4] Engr., Superheater Co., New York, N. Y. Assoc-Mem. A.S.M.E.
[5] Engrg. Mgr., Thos. E. Murray, Inc., Mem. A.S.M.E.
[6] Bailey Meter Co., Cleveland, Ohio. Mem. A.S.M.E.
[7] Cons. Engr., Johns-Manville Co., New York. Assoc-Mem. A.S.M.E.

that heat was transmitted much more readily from saturated steam to a surface than from superheated steam. However, granting a large difference in transfer coefficients from saturated and superheated steam to pipe wall, the question was, how much difference would this make in actual heat losses?

The value of α for saturated steam used by the author was over twelve times that for superheated steam and it would be only natural to expect that the loss from the saturated-steam pipe would be far larger than that from a superheated-steam pipe at the same temperature. Such would be the case if the transmission of heat from steam to pipe wall were the only factor involved, but the heat must be transmitted from the outside of the pipe to the air, or through insulation to the air. Therefore the additional resistance to heat flow was so great outside of the pipe that the difference in inside resistances became very small in comparison.

In the case of bare pipes there were larger differences, but even with bare pipes the differences were of the order of only 10 per cent. These differences, however, were of little importance as few bare pipes were used for the transmission of superheated steam.

Most published tables on heat losses from bare pipes were based on loss per square foot per degree temperature difference between *pipe surface* and air. These were therefore correct for the stated condition, regardless of what was inside the pipe.

Referring to Table 4, in which a lower radiation loss per pound of steam was shown for superheated steam than for saturated steam, this result was based entirely upon the assumption that the velocity in superheated-steam lines was exactly double the velocity in saturated-steam lines. This table showed higher actual radiation losses on the superheated-steam lines, but on the basis of the doubled velocity so much more steam was passed through the superheated-steam lines that the loss per pound was shown to be less. An explanation of just why the author assumed a doubled velocity in the superheated steam line instead of some other ratio would be necessary in order to give significance to this table.

In fact, it was Mr. McMillan's understanding that the practice of calculating steam-line sizes on an assumed velocity was antiquated and that the preferred method was one based on allowable pressure drop.

L. L. Barrett[8] stated that those engineers who had occasion to consider the heat losses from bare pipe lines conveying steam would be grateful to the author for his presentation of extracts from Eberle's paper which had never before been translated into English.

Referring to the tables in the paper, the heat losses on which Tables 1 and 2 were based had been obtained by weighing the water condensed in the pipe line under test. This method was inaccurate, as stated by the author, and the later determinations of McMillan, Bagley, and Heilman were preferable. The constancy of the value of K for the covered 3-in. line in Table 2 was a good illustration of the inaccuracy of this table. Both McMillan and Bagley had shown that this value would vary considerably with the temperature difference.

The comparison in Table 4 was based on the assumption that all the condensation from the saturated steam lines was wasted. It could not be admitted that this was the general practice in power plant or marine work. In such cases it was almost the invariable practice to return the condensation to the boilers. Any other practice would be most wasteful and would result in a poor showing for the heat cycle of the plant.

It would be interesting to know on what basis the radiation losses for superheated steam in Tables 4 and 6 had been figured where the steam velocities were shown as 7000, 8000, and 10,000 ft. per min., as the highest steam velocity on which data were given in the paper was but 5910 ft. per min.

Referring to the author's summary (appended to the complete paper) no data were given to support the heat-transmission coefficient between steam and pipe wall of 400 for saturated steam there mentioned. The values of this coefficient found in the experiments of Clement and Garland at the University of Illinois ranged from 1649 to 2740 and the value found by McAdams and Frost at the Mass. Inst. of Tech. in 1922 was 2400.

[8] Mgr. Engrg. Dept., Keasbey & Mattison Co., New York, N. Y. Assoc-Mem. A.S.M.E.

The author's conclusion that the coefficient of heat transmission from steam to air remained practically constant up to a temperature of 350 deg. fahr. was disproved by the work of McMillan, Bagley, and Heilman, all of whom showed a very large increase in the coefficient between 100 deg. and 350 deg. fahr. in the case of bare pipe. The increase in the coefficient from 100 deg. to 350 deg. temperature difference was 60 per cent according to Heilman's paper.

The author, in his closure, said that it was very true, as had been stated by Mr. Barrett, that the analysis of radiation losses in pipe lines in the paper was not based on the experiments of Messrs. McMillan, Bagley, and Heilman, all of which were made with electrically heated pipes, and the object of which was mainly to determine the efficiency of various types of pipe covering. His paper was not intended for this purpose. Its object, particularly the first part dealing with radiation losses, was to show, first, that there was a difference between saturated and superheated steam as far as imparting of heat to a pipe wall was concerned; and second, that in comparing the radiation losses of saturated and superheated steam, not the direct heat in B.t.u. was to be considered, but the total heat losses in percentage of the heat conveyed in the steam through the pipe. As the Munich tests were believed to be the only extensive ones conducted with saturated and superheated steam flowing in the test pipe, only these tests could be considered and analyzed in the paper.

Mr. Barrett had looked at the paper only from the standpoint of pipe covering, and therefore had noticed only the data showing the radiation losses. If he would look upon the paper as an engineer and would consider steam velocities, temperature differences, pressure drops, etc., he would better realize the object of the paper and would understand the analysis presented.

Mr. Barrett objected to value of 400 given as the heat-transmission coefficient between the steam and pipe wall because other investigators had found it to be considerably higher, or up to 2700. From Table 1 of the paper it would be seen that at a temperature difference between the steam and the outside air of 250 deg., the heat loss per square foot of surface per hour in B.t.u. was 750. With a heat-transmission coefficient of 400, the temperature of the wall must be $750 \div 400 = 1.875$, or less than 2 deg. below the steam temperature. At a wall temperature equal to the steam temperature, the coefficient would be infinitely large. As it was very difficult to measure accurately the temperature of the steam and the pipe wall, and a difference of 2 deg. was likely to occur, the value of coefficient could not be definitely fixed. Four hundred was mentioned in this paper only as a comparison with the value of superheated steam, which was only 32 at a velocity of about 80 ft. per sec.

As Mr. Armacost had said, the difference between the data of the tests analyzed in the paper and those of Messrs. McMillan, Heilman, and others, was very slight.

Mr. McMillan wondered why the difference between the heat transmission of saturated and superheated steam had been gone into in such detail. As mentioned early in the paper, this subject was of considerable interest as far as the use of superheated steam for heating and drying purposes was concerned. So far as the author was aware, the influence of the velocity of superheated steam on the heat transmission, particularly in connection with the question of whether the pipe was wet or dry inside, had never before been discussed, and was believed to be of considerable interest to engineers.

The velocities taken in Table 4 were in accordance with general engineering practice. The pressure drop was only slightly higher than that for saturated steam and, with the exception of one case, did not exceed 1 lb. throughout the range of the table.

With reference to the question asked by Mr. C. W. Gordon[9] as to why the friction in pipe lines at high pressures was less, while in fittings it was higher than that derived by calculating according to standard formulas for moderate steam pressures, he would say that this was probably due to the fact that in fittings the steam changed its direction and a part of its kinetic energy was lost, and that this was more pronounced at higher pressures than at the lower ones.

[9] Exper. Engr., Superheater Co., New York, N. Y. Jun-Mem. A.S.M.E.

Management Engineering in the Paper Industry

The Measurement of Performance a Factor in Good Management—Industry Should be Organized to Encourage Rather than Repress Individual Development

By R. B. Wolf,[1] New York, N. Y.

The most difficult problem that the paper-mill manager has to solve is the problem of overcoming the resistance of the practical operators to the introduction of scientific manufacturing methods. He must depend upon his superintendents, department heads, and foremen for the carrying out of his ideas, and if he can produce in them a desire to improve existing conditions, rapid progress can be made.

The reason the so-called practical operator finds it difficult to follow the scientific or inductive method is that he has not been taught how. The things he knows about paper making he has learned by seeing the things happen. His knowledge, therefore, is made up of a great many more or less disconnected facts, which, due to a lack of scientific training, he has not learned to put together into principles or laws. This in no sense reflects discredit upon the practical man. He has simply lived his life in an environment where it has not been customary to use the scientific method of keeping accurate records of his past experiences. The lack of ability to develop general principles from particular instances can be overcome only if the management encourages the operators, particularly the department heads and foremen, to record the various happenings so that they can be studied in their relationship to one another.

In the past four or five years great progress has been made in measuring the quality elements in paper, and numerical values have been given to such elements as strength, weight, moisture, finish, formation, cleanliness, bulk, and color. In each case a numerical value indicates the nearness to an ideal 100 per cent standard.

One large company has for some time made it a practice to compare the output of each of its mills with the product of a number of outside mills, with whom samples are exchanged, recording in this way the individual performance of each producing unit. Of course such records stimulate interest in the factors which affect the various quality elements. For instance, both weight and moisture are affected by the amount of water in the stock flowing on to the wire of the paper machine, the slowness and freeness of the stock, the amount of agitation in the flow box of the paper machine, the stock proportions in the furnish, the pitch of wire, and many other factors of a similar nature. It is important to note that interest in recording these factors has been aroused by the discovery that the only way to control the quality elements is to control the factors which affect them. This control, however, is not possible, unless the management provides means for keeping individuals who are responsible for variations in quality constantly informed as to what is happening.

The science of paper making in the past has been too much like the old pseudo-sciences, where sense impressions governed. The immense waste attending the use of such methods makes it imperative for us to change them. There is plenty of evidence that the art of paper making is beginning to be based upon real scientific knowledge, and the publication of a complete set of textbooks by the Canadian and American Technical Associations is the best testimony that a genuine spirit of scientific inquiry is developing in the paper industry. As a result of this excellent piece of work it is now possible for the student of paper making to familiarize himself with the best paper-making practices of the past, and the manufacturer can avoid much costly duplication and experiment.

To insure continued progress, however, it is necessary that the group leaders become more skilful in recording and evaluating manufacturing processes. This evaluation of progress, however, is an individual thing and it is therefore necessary to understand the nature of the individual, particularly that very important individual, the superintendent or foreman, who will quite naturally block any effort to introduce methods which he does not himself understand. Any one who has ever tried it knows that scientific record keeping, by technically trained men, will bring to light many practices that should be changed, and this, of course, puts the head of the department on the defensive. He feels that he is *supposed* to know all about his job and in spite of assurances that he could not be expected to know what was not known before, he will, in the great majority of cases, remain on the defensive.

Departmental Cost Sheets Stimulate Economy

Our own experiences have taught us that the best way to produce an open-minded attitude is to introduce a system of departmental cost sheets, which will reflect the economy of operation in each department. No superintendent or department head will object to the introduction of such economy records, and the far-reaching effect of such a cost-keeping system will be seen by a few instances taken from actual experience.

In one plant the introduction of steam meters in order to charge the steam used to each operating department led to such an interest in steam usage that it was possible to avoid the installation of a new boiler, and finally to shut down the spare boiler which it had been previously necessary to keep in almost constant use. The department heads were no longer indifferent to leaky traps on the steam coils, poor insulation on steam pipes, the excessive use of steam in manufacturing processes, etc., for all of the steam used by the department had to be paid for and reflected itself in the cost sheet as uneconomical performance. Not only did the operating department head take an interest in the amount of steam used, but also in the cost of steam. So it followed that the head of the steam department soon found it necessary to know why the cost of making steam was high. Then came the installation of steam meters on each individual boiler unit, and the measurement of coal to each unit so that evaporating efficiency could be determined. Draft gages, CO_2 recorders, etc., of course, followed, for without them the reasons for low evaporation could not be known, but only guessed.

The important thing to remember is that intelligent cost keeping is sure to produce a demand from within the department for the introduction of scientific record keeping which will explain variations in cost, whereas the introduction of scientific methods without first stimulating an interest in economy of operation usually arouses suspicion.

Departmental cost sheets, which show the actual cost of stock in the paper, will soon bring about an inquiry as to the reasons for high shrinkage, and a demand for accurate records of the fiber losses invariably follows. One important development along this line has been the working out of a method for making continuous moisture determinations in the paper coming off the paper machines, making it possible for the machine operator to save stock by not overdrying the paper. The use of this method in the newsprint industry alone has saved literally hundreds of thousands of dollars, for, as shown by the figures of the News Print Service Bureau, an average of considerably over one per cent more paper is now obtained from the same raw materials.[1]

Maintenance of Individuality a Prime Necessity

In his paper on Non-Financial Incentives[2] the author showed the very great savings made in repair materials when cost records were furnished to responsible individuals in a large manufacturing organization, so further illustration is not needed. What it seems to him is needed, however, is a clear understanding of what constitutes individuality. If those entrusted with the direction of our industrial

[1] The R. B. Wolf Company, New York, N. Y., Mem. A.S.M.E.

Contributed by the Forest Products Division for presentation at the Spring Meeting, Montreal, P. Q., Canada, May 28 to 31, 1923, of The American Society of Mechanical Engineers. All papers are subject to revision.

[1] Approximately 2,500,000 tons of news paper is made a year. Assuming an average price of \$35 per ton for raw materials in this paper, a conservative estimate of $1^1/_4$ per cent increase in the moisture test shows a saving of over \$1,000,000 a year.

[2] Trans. A.S.M.E., vol. 40 (1918), p. 925.

plants do not have a clear understanding of this principle, they cannot effectively instil the principles of sound economics into their organization.

John H. Williams pointed out before the Cost Accountants Association, at Cleveland, that the first thing to do before a cost system is set up is to determine managerial responsibility. Once this is done the group individuality becomes clearly defined and quality and quantity records are sure to follow. Science, in other words, will replace "rule of thumb."

There is, perhaps, no principle of life which is so difficult to understand as this principle of individuality. "Who can tell," says Bergson, "where individuality begins or ends; whether it is the cells which associate themselves into the organism, or the organism which dissociates itself into the cells?" The principle, however, must be understood, for otherwise mankind is doomed to eternal conflict with his fellow-men.

In no other period of the world's history has the group spirit found such material expression as in this twentieth-century development of corporate industry. In the past men have combined into groups for productive purposes, but never before have we seen such grouping of groups and these larger groups into still larger corporate units, and the startling fact is that most of this has taken place within the lifetime of the men who are still in active charge of industry. What is the meaning of it all, and what is to become of the individual men in the process? This, the author believes to be the most momentous problem confronting modern civilization, for if it is not solved, civilization as now constituted cannot last. To crush out the individuality of the workman is fatal to human progress and it is also fatal to destroy the individuality of our manufacturing or producing units.

One of the very first things to recognize about the principle of individuality as related to industry is that it has three modes of expression in any given plant:

First, it expresses itself through each individual worker

Second, it expresses itself through each individual group, or department, which has a specific function to perform; and

Third, it is expressed by the plant as a whole.

The next thing to recognize about individuality is that its purpose is to record a lapse of time. Progress must be made from one point in time to another point in time, and it is the very essence of individuality to preserve a record of the changes which have occurred between a sequence of time periods. To illustrate: the year is usually divided into twelve monthly periods and for each month we have records of Quantity of Paper Produced, Quality of Paper Produced, and Cost of Paper Produced. It is only by studying these records of *past* performance of the plant as a whole that we can get a sense of what has been accomplished and, what is more important, a vision of what may be accomplished in the future.

The plant, however, is made up of departments, each of which contributes its individual share to the enterprise. Therefore, to get the most effective results, similar monthly records should be kept for each department, such as the quantity, quality, and cost of pulp produced; the quantity, quality, and cost of steam produced; or the quantity, quality, and cost of the output of each department of the plant.

Finally, all departments are composed of individual men and we have found it equally necessary to the cause of sane and rational progress to record for the workman's benefit the quantity, quality, and cost of performing his work. It is not always practical to record all of these factors, but always one can be recorded, sometimes two, and sometimes all three. It goes without saying that the workman who is conscious of all three will see how his own job is related to the process as a whole and can work with a much greater degree of intelligence.

The periods or points in time between which the records enable us to note changes, vary in both duration and frequency of occurrence. In processes where rapid changes occur, as in the weight of paper on paper machines, or temperatures in cooking digesters, the periods are short and are usually measured by minutes; in the case of average temperatures, paper-machine speeds, or evaporation records the periods are longer and are measured by hours; and in the case of many quantity, quality, and cost records the periods represent averages for days, weeks, or months.

In each case, however, it should be noted that we are measuring the progress of a producing unit and that these individual producing units are either men, groups (operating departments or divisions), or the plant as a whole.

It is not difficult to visualize the concrete reality of the first of these producing units, the man. It is difficult, however, to visualize the essential unity of the department or the unity of the plant itself, of which the department is an individual member.

There is perhaps nothing more concrete and practical and at the same time more abstract and theoretical than this problem of developing these indivisible group individualities. The author feels sure that the way out is to come to a realization that the purpose of the individual is to create, whether the individual is a *man* creating (converting) pulp from wood on a grinder, a *department* creating chlorine liquor from salt and lime, or a *plant* creating paper from wood, clay, size, color, and all the various raw materials which furnish the energy or the substance used in the manufacturing process.

As indicated before, the answer seems to lie in increasing our skill in recording and evaluating the manufacturing process, so that consciousness of what has happened in "times" past may stimulate an interest in improvements to be made in "times" to come.

Just as the man's interest in the future economy of his own performance is aroused by making him conscious of the economy with which he has performed in the past, so must the group consciousness of economy be aroused by providing a record of past group performance. Unless group individuality (*esprit de corps*) is developed there can be no sense of responsibility and hence no progressive group accomplishment. It is obvious, therefore, that we must develop records for enabling the individuals who comprise the group to be conscious of what the group, *as a unit*, is accomplishing. Without this definite knowledge of progress made there can be no coöperative teamwork and the progress will be in the direction of quantity, with little thought of improvement in quality of performance or economy of operation.

What is true of the group or department is of course equally true of the plant as a whole, so each individual department must be conscious of the effect of its own activities upon the finished product. The point that must not be lost sight of is that this is not possible without a constant recording of the effect of variations in departmental products upon the finished product.

Quantity, quality, and cost should all be recorded, and if these records are kept *of* men, departments, and plant and made available *to* men, departments, and plant, there will be released very great creative power in the only way it can be released, namely, through the individual, whether that individual be a *man*, a *department*, or a *plant*.

"Our social economic system cannot march toward better days unless it is inspired by the things of the spirit. It is here that the higher purposes of individualism must find their sustenance."[1] Herbert Hoover, who says this, has a concrete record of accomplishment to his credit which makes these mystical words take on new meaning, especially when taken with his expressed conviction that "permanent spiritual progress lies with the individual."

Yes, the individual must be understood, and the whole problem of industry, it seems to the author, resolves itself into finding out how to enable the unit individual, the man, to become conscious of his relationship to the all-including group individual, the plant; and how to organize the plant so that it will be sufficiently sensitive to the welfare of the human units of which it is composed that it will not repress but encourage their individual development.

The secret seems to lie in stimulating group consciousness within the organic whole of the plant by continuously recording the group's relationship to the plant on the one hand, and the man on the other, and the immediate need seems to be for the education of foremen to intelligently direct the groups. This education, however, to be of use, must be largely obtained from a study of records of group experiences, for information obtained in this way constantly stimulates the individual to greater effort. The recorded results of this new effort will act again as a fresh stimulus, so that continuous progress in both knowledge of process and skill in the use of his knowledge is bound to follow.

[1] American Individualism, by Herbert Hoover, published by Doubleday, Page & Co.

The Oil Venturi Meter

Measurement of the Flow of Viscous Fluids with the Venturi Meter—Decrease of Coefficient with Turbulence—Influence of Viscosity—An Accurate Method of Calibration

By ED. S. SMITH, JR.,[1] LOS ANGELES, CAL.

THE venturi meter furnishes a means for accurately measuring the flow of liquids and gases in pipe lines within certain limits. These limits, however, must be known, and they are determined by the corresponding values of the turbulence, also known as Reynolds' criterion and defined by the method of dimensions as Qg/du. In the following paragraphs the author presents an accurate method of calibrating the venturi meter, shows the limit for accurate measurement, and brings out the fact that the viscosity of the fluid has considerable effect and must be accurately known. The theory underlying the method described is not essentially new, but has been discussed by W. J. Walker and W. N. Bond as noted in references at the end of the paper.

In order to use the venturi meter with accuracy there must be known not only the size and form of the tube but also the viscosity and density of the fluid. There are several standard viscosimeters in common use in the oil industry which are used to determine the viscosity of liquids with commercial speed and sufficient precision.

The values of the coefficient of the venturi meter have been determined for a wide range of turbulences. The coefficient approaches unity at high turbulences but drops rapidly just above the upper critical turbulence and approaches zero as the turbulence approaches zero. This falling off of the coefficient is due chiefly to the increase of the friction pressure loss of the tube relative to the theoretical pressure drop, i.e., that pressure drop causing the increase of velocity from the entrance to the contracted throat of the meter.

Fig. 3 is an example of the most convenient form of calibration for actual use, and is the result of two years' use of this method of calibrating the venturi meter with viscous oils.

Calibration by the Method of Dimensions

The increasing use of continuous processes in the oil-refining and other industries is bringing the venturi and other continuous flow meters into common use for the measurement of a large variety of fluids. As the viscosity of liquids may now be commercially determined, it is possible to use these meters with a method of calibration which is both simple and exact.

The method of dimensions has been in use for several years in the computation of friction pressure loss in pipe lines carrying viscous oils.[2]

The calibration has been extended to low values of the turbulence by employing data obtained by the author in tests conducted on a model venturi meter at the University of California. Grateful acknowledgment is made to Dr. Baldwin M. Woods, professor of aerodynamics, and to L. C. Uren, professor of petroleum technology, both of that institution, for their generous assistance.

The symbols and formulas used are as follows:

Q = quantity, U.S. gal. per min
q = quantity, cu. ft. per sec.
u/g = kinematic viscosity, sq. cm. per sec.
u = absolute viscosity, grams per cm-sec.
g = density (specific gravity, approximately), grams per cu. cm.
d = diameter of pipe, i.e., the same as the approach to the venturi tube, in.
a = cross-sectional area of pipe, sq. ft.
H = differential head of liquid in venturi tube from the approach to the throat, ft.
h = differential head of mercury in manometer measuring H, in.
C = coefficient for the venturi meter, see Equation [1]
P = friction pressure loss in pipe line per 1000 lin. ft., lb. per sq. in.
k = coefficient for friction pressure loss in pipe line, see Equation [2]

$$q = C \times a_2 \times \frac{a_1}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2 \times 32.2 \times H} \quad \ldots\ldots [1]$$

$$P = k \times g \times \frac{Q^2}{d^5} \quad \ldots\ldots [2]$$

Fig. 1 shows the value of the venturi-meter coefficient C as determined by actual experiments over a range of turbulence from 0.0003 to 200,000.

The friction-pressure-loss coefficient for pipe lines is also shown, the lower critical turbulence a occurring at 64 and the higher critical turbulence b at 85. From zero to 64 the flow is known as "viscous" or "streamline" flow, and the friction loss varies as the first power of the velocity. From 64 to 85 the flow may be termed "superturbulent," as the friction pressure loss varies as the cube of the velocity. From 85 to infinity the flow is known as "turbulent" or "hydraulic," and the friction pressure loss varies as a power of the velocity (the 1.75 power for smooth steel pipe lines such as are ordinarily used for oil transportation), with the square of the velocity as the upper limit for very rough pipe.

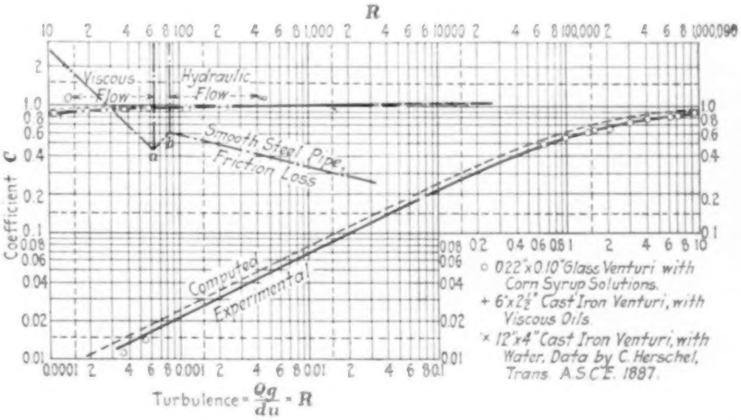

Fig. 1 Values of Venturi-Meter Coefficient C as Determined over a Range of Turbulence from 0.0003 to 200,000

As the coefficient of the venturi meter is partly dependent upon the friction pressure loss along the venturi tube, it is apparent that the law of variation of the coefficient with the turbulence will not be the same for the three types of flow and that consequently the graphical method of handling the coefficient is preferable to the use of an algebraic formula.

Fig. 2 provides an accurate calibration for the two types of venturi meters in common use in the United States, the Builders Iron Foundry and the Simplex Standard.

The Builders Iron Foundry tube has faired lines and consequently the higher coefficient. This calibration is for meters having a ratio of approach diameter to throat diameter of approximately 2.5 to 1, and is strictly correct for a 6-in. meter only—larger sizes having slightly higher coefficients and smaller sizes slightly lower coefficients. However, it is accurate enough for oil measurement under commercial conditions.

The Simplex Standard tube has a ratio of diameters of 2 to 1, and all sizes are made closely similar in form. The sharper changes from the cylinders of the approach and throat to the cone cause the coefficient to be slightly lower than for the other type of meter, but its accuracy is as high since it is necessary with both types of meter to use a calibration when measuring viscous oils.

Example in the Use of Fig. 2. Determine the quantity of oil flowing at 130 deg. fahr. through a 6-in. by 2½-in. venturi tube (Type B.I.F.) when the mercury-oil differential h = 4.2 in., the kinematic viscosity u/g = 0.11 sq. cm. per sec. (from 64 sec. Saybolt), the density of the oil flowing is g = 0.90 gram per cu. cm. (from 26 deg. B.), and the density of the same oil at 60 deg. fahr. above the mercury in the manometer is 0.94 gram per cu. cm. (from 20 deg. B. at this temperature).

[1] California National Supply Co.

[2] See The Friction Pressure Loss in Oil Pipe Lines, compiled by R. S. Danforth and published by the Kinney Mfg. Co., of San Francisco, Cal.

Presented at the Pacific Coast Regional Meeting of The American Society of Mechanical Engineers, Los Angeles, Cal., April 16–18, 1923.

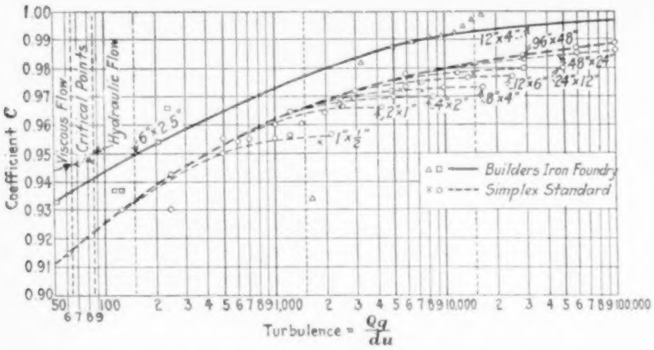

Fig. 2 Calibration for Two Types of Venturi Meters in Common Use in the United States

Since $d_1 = 6$ in., $a_1 = 0.196$ sq. ft.; also, from $d_2 = 2\frac{1}{2}$ in., $a_2 = 0.0341$ sq. ft. Substituting these volumes in Equation [1],

$$q = C \times 0.0341 \times 1.016 \times 8.02 \times \sqrt{H}$$

$$= C \times 0.278 \times \sqrt{H} \text{ cu. ft. per sec.}$$

For a first approximation, assume $C = 0.95$; then

$$Q = 448.9 \times 0.95 \times 0.278 \times \sqrt{\frac{13.6 - 0.94}{12 \times 0.90}} \times \sqrt{4.2}$$

$$= 263 \text{ gal. per min.}$$

But $Qq/du = \dfrac{263}{6 \times 0.11} = 400$, and from Fig. 2, $C = 0.962$; therefore

$$Q = 0.962 \times 278 = 267 \text{ gal. per min.}$$

which is the quantity flowing under the conditions stated above.

Fig. 3 consists of Q-h curves for each of several viscosities of oil. The full lines are accurate to 1 per cent. The broken lines are in the viscous-flow region and are of undetermined reliability. The density correction for the head h is applied by the graph at the left side of the figure. A graph for the conversion of Baumé density to specific gravity (density in grams per cu. cm.) is attached to the upper side of the density-correction graph and shows the correction for the increase of density with a rise of temperature of the oil above 60 deg. fahr. At the right of the density-temperature graph is a small sheet of logarithmic cross-section paper for plotting viscosities at various temperatures of the oil which is being measured. The kinematic viscosity of ordinary petroleum oils, when plotted against temperature on logarithmic cross-section paper, forms a nearly straight line. As an example three plotted points are shown for a viscous California oil. At some higher temperature than 200 deg. fahr., this line is discontinuous for most petroleum oils and another nearly straight line holds for higher temperatures. The conversion from Saybolt viscosity to kinematic viscosity is given on the upper margin of this graph. The viscosity of oil at any temperature, as shown on this graph, is used to indicate the proper curve to use on the Q-h graph. This same group of auxiliary graphs may be used with any size of venturi meter, it being necessary to change only the Q-h graph.

Example in the Use of Fig. 3. Determine the quantity of oil flowing under the same conditions as in the example illustrating the use of Fig. 2.

Referring to Fig. 3, follow the arrowed dot-and-dash line for the 4.2-in. mercury-oil deflection from the left side of the density-head diagram to the 0.90 vertical density line, then up the diagonal to the corrected deflection $h = 4.68$ in. Follow this horizontal dot-and-dash line to its intersection with the diagonal 0.11 kinematic viscosity line (obtained by interpolation). Reading vertically down from this intersection it is seen that the quantity of oil flowing under these conditions is 267 gal. per min.

Limits of Accuracy of the Calibrations

The data submitted in Fig. 2 for the Builders Iron Foundry venturi tube are accurate to within 1 per cent for tubes of similar form (2.5:1 ratio of approach to throat diameter) for 2-in. to 12-in. diameter tubes in the region of turbulent flow, since the data in this region are calibrations of full-size venturi tubes with lathe-turned bronze or cast-iron throats.

This calibration applies strictly to 6-in. diameter tubes only; because the tubes to be similar in form must have the roughness increase directly with the size of the tube, i.e., the size of the rugosities must be in proportion to the diameter of the tube. The use of equally rough (or smooth) surfaces for all sizes of meters causes the coefficient to be slightly higher for larger meters for all turbulences in the region of turbulent flow. The degree of roughness does not appreciably affect the coefficient of the venturi tube in the viscous-flow region.

The data in the viscous-flow region are not as accurate as those in the turbulent-flow region. The former are from a calibration made by the author on a 0.22-in. by 0.10-in. home-made model glass venturi-meter tube with water and corn-syrup solutions. The venturi tube was drawn from a straight glass tube and, while not exactly similar in form to the Builders Iron Foundry tubes, approached it closely enough to show definitely the type of variation of the coefficient to be expected for full-scale venturi tubes. The kinematic viscosity was determined with home-made pipette viscosimeters calibrated with water. In spite of the care used to avoid the effects of surface tension and velocity head, and because these viscosimeters measured solutions more than a thousand times as viscous as water, the probable accuracy of the viscosity determinations is approximately 90 per cent. This would mean an expected error of about 10 per cent in the turbulence for the values of the coefficient in the viscous-flow region.

For the purpose of checking the viscous-flow data obtained with the model glass venturi tube, the theoretical coefficient of a 6-in. by 3-in. Simplex venturi tube was computed. It was assumed that the only sources of loss of head from the approach to the throat were those due to the friction loss along the tube and the building up of the kinetic energy of the fluid in the throat. Poiseuille's formula for the friction loss of fluids in viscous flow in cylindrical tubes was used without modification for the approach and the throat. The friction loss in the cone was computed using the integral calculus and the same formula. From the sum of the change

(Continued on page 331)

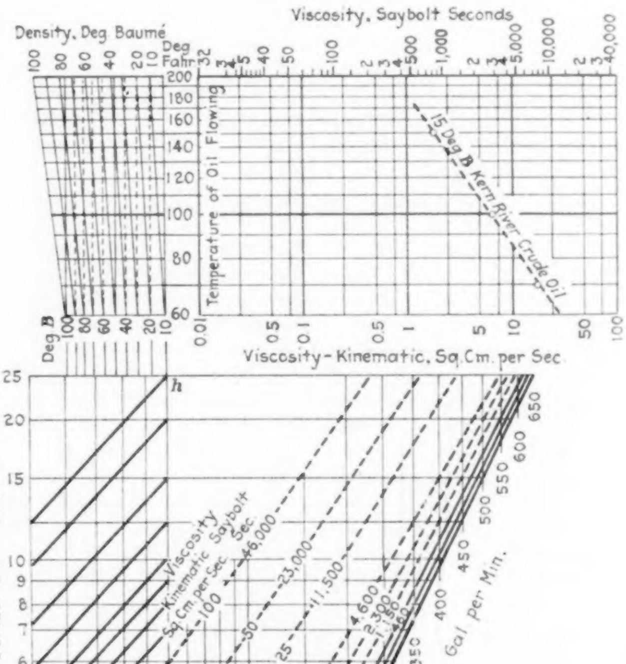

Fig. 3 Flow Graph for a 6-in. by $2\frac{1}{2}$-in. Builders Iron Foundry Venturi Meter

Boiler-Furnace Design

The Tendency in Modern Power Stations Toward Larger Combustion Space—Factors Governing Furnace Volume—The Construction of Boiler-Furnace Walls

By EDWIN B. RICKETTS,[1] NEW YORK, N. Y.

THE FUNCTION of the boiler furnace is to supplement the grate or fuel burner in transforming the energy of the fuel into heat and to transfer that heat to the boiler; and the measure of the efficiency of a furnace is the degree of completeness of combustion at the point where the gases enter the boiler tubes and the degree of availability for absorption by the boiler of the potential heat in the fuel at the point where it is delivered to the boiler for absorption—in other words, the percentage of excess air which is necessary to produce complete combustion at the point of exit from the furnace.

Last fall in connection with the preparation of the Stokers and Furnaces Section of the Prime Movers Committee Report, the author undertook an investigation for the purpose of determining what relation, if any, existed between the relative volume of the furnace and the efficiency of a boiler. This investigation occupied most of the time of several men for three or four months, but in spite of the large amount of time and thought expended, none of them was able to draw any definite conclusions from the data available. However, the importance of and general interest in the question justify reviewing briefly some of the facts which this investigation has so far brought to light in the hope that by broadening the field of the investigation others may solve the problem where, due to his lack of information, the author has been unsuccessful. A few years ago it was a very rare thing to find boilers provided with more than 1 to $1^1/_2$ cu. ft. of furnace volume per rated hp., but the tendency in modern power stations is very strongly toward much larger combustion space. An idea of what is becoming general practice today may be obtained from Table 1, which gives the cubic feet of furnace volume per rated hp. in a number of our newest power stations. In the chain-grate stoker field it will be noticed that this ratio runs from 2 in the case of the American Sugar Refining Company's plant in Baltimore to a maximum of 5.75 at Waukegan. With underfeed stokers it varies from 2.17 at Dodge Bros. to 4.80 at the Delaware station. With pulverized coal at Lakeside 4.56 cu. ft. was provided, which is being increased to 6.52 at Cahokia, and the author knows of installations at present still in the preliminary stage which will probably have a ratio as high as 10.

TABLE 1 CUBIC FEET OF FURNACE VOLUME PER RATED HORSEPOWER (10 SQ. FT. BOILER HEATING SURFACE)

Station	Chain-grate stokers	Underfeed stokers	Pulverized coal
RECENT STATIONS			
American Sugar-Baltimore	2.00	..	..
Kansas City	2.57	..	..
Dalmarnock-Glasgow	3.10	..	..
Barking-London	3.87	..	..
Calumet	4.45	..	..
Waukegan	5.75	..	..
Dodge Bros	..	2.17	..
Seward	..	3.24	..
Colfax	..	3.45	..
Springdale	..	3.95	..
Hell Gate	..	4.23	..
Gennevilliers-Paris	..	4.50	..
South Meadow	..	4.56	..
Delaware	..	4.80	..
Lakeside	..	..	4.66
River Rouge	..	..	4.98
Cahokia	..	..	6.52
OLDER STATIONS			
Waterside	..	1.05	..
Essex	..	1.95	..
Muscle Shoals	..	2.19	..
L. Street	..	2.43	..
Connors Creek	..	2.72	..

Table 2 gives, so far as the author has been able to learn, the highest B.t.u. fired per cubic foot of furnace volume per hour on tests where the efficiency of boiler furnace, grate, and superheater was approximately 80 per cent (78 to 82 per cent). Of the coal-firing systems pulverized coal is seen to require by far the largest furnace volume, whereas the same efficiency has been obtained on hand-fired Scotch marine boilers when burning seven times as much coal per cubic foot as has been found best suited for powdered-coal installations.

Factors Governing Furnace Volume

The furnace volume required for the complete combustion of any fuel is a function of many variables, among the more important of which may be mentioned the physical state and chemical composition of the fuel, the type of fuel-burning equipment used, the shape of the combustion chamber, and the means provided for mixing the fuel and air in the furnace.

Physical State and Chemical Composition of the Fuel. On account of its chemical composition and physical state fuel oil when burned in modern mechanical atomizer burners is almost ideal in the furnace volume required for its complete combustion. As much as 265,000 B.t.u. per cu. ft. per hour has been obtained on a White Foster boiler with an efficiency of 76 per cent. This is due to the fact that a large part of the work which in old-style burners was performed by the furnace is now accomplished in the burner itself. Oil is heated to about its flash point and blown into the furnace thoroughly atomized and mixed with the requisite quantity of air for combustion, resulting in a very sharp and intense flame accompanied by complete combustion within a few feet from the mouth of the burner.

Next in order to oil are the lump grades of low-volatile coal. With fuel of this kind the greater part of the combustion takes place within the fuel bed itself or within a very short distance above it. The gas and air leaving the fuel bed are thoroughly mixed and very little furnace volume is required for the completion of combustion. With the higher-volatile solid fuels, particularly if they are fired in the form of slack, large amounts of gaseous products are distilled from the fuel bed and frequently the air and gas are in a more or less stratified form, requiring either a considerable distance of travel or the provision of certain mixing arrangements in order that the gas may be completely consumed before reaching the cooling surface of the boiler.

Type of Fuel-Burning Equipment. Of the types of mechanical fuel-burning equipments in common use, the mechanical atomizer oil burner, for the reasons stated above, requires the least help from the furnace. Next in order probably comes the underfeed type of stoker. In underfeed stokers provided with means for continuous ash discharge, due to the depth of the fuel bed and the multiplicity of air openings, a large part of the combustion takes place on the grate and a fairly uniform mixture of air and gases is delivered to the furnace so long as the fire is kept free from holes and large clinkers. Some stratification may take place when too much air is admitted from side-wall ventilating systems, but this difficulty is usually easily overcome by altering the size and position of these air openings.

TABLE 2 B.T.U. FIRED PER HOUR PER CUBIC FOOT OF FURNACE VOLUME AT EFFICIENCIES OF ABOUT 80 PER CENT WITHOUT ECONOMIZERS

Fuel-burning system	B.t.u. per cu. ft. of furnace volume
Pulverized coal	22,000
Chain-grate stokers	37,500
Underfeed stokers	64,000
Locomotives	70,000
Oil—steam atomization	85,000
Scotch marine boiler, hand-fired	144,000
Oil—mechanical atomization	176,000

Chain-Grate Stokers. That part of the combustion which takes place on the grate of a chain-grate stoker is considerably more complicated than it is in the case of an underfeed type of stoker. Fuel enters the furnace at the front end of the grate where it must be ignited by reflected heat from an incandescent arch. In this ignition process large volumes of gas are driven off and there is usually a considerable deficiency of air. As the fuel passes further on into the furnace fairly complete combustion takes place on the

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grate in the center zone, while in the rear end of the stoker the last of the carbon is burned out, accompanied by a considerable excess of air. There are thus three streams of gas leaving the grate, each being very different in composition, ranging as they do from a stream of gas at the front end mixed with insufficient air for combustion to another mixed with a large excess of air at the rear of the furnace. If provision is not made in the furnace for bringing together and mixing these gaseous streams incomplete combustion may result, as well as a large excess of air.

Pulverized-Fuel Systems. In the systems for burning pulverized fuel which are finding the most successful applications today, the fuel together with probably 25 or 30 per cent of the air requisite for combustion is wafted into the furnace in such a way as to give it as long a travel as possible before reaching the tubes, and the

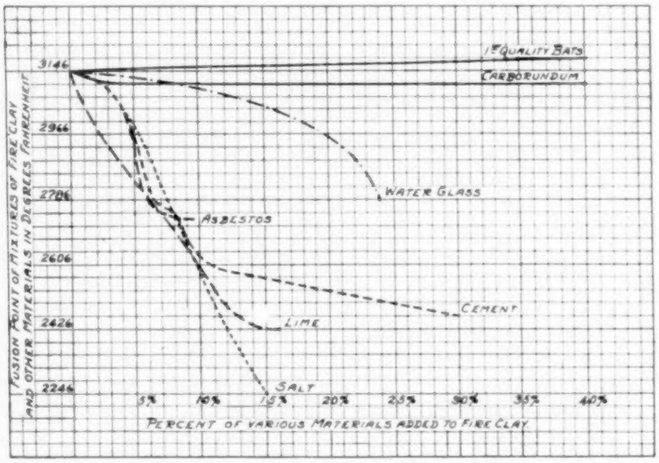

Fig. 1 Effect on the Melting Point of the Resulting Mixture of Adding Various Materials to Fireclay

air necessary to complete combustion is brought into the furnace through a multiplicity of openings so arranged as to bring fresh streams of air in contact with the coal particles at successive intervals as they travel through the furnace; while the particle of powdered coal is very small, if it is to be consumed with a minimum of excess air, it is obvious that it must have a long period in the furnace in order to find and combine with those air molecules which are provided for its combustion.

Shape of Combustion Chamber and Mixing Arrangements. It is obvious that a thorough mixture of the fuel and air must take place somewhere in the burning system. If this is not done by the burner or grate, it must be brought about within the furnace. In the mechanical atomizer oil burner practically all of the mixing is done in the burner itself. Consequently no mixing arrangements are required in the furnace. In the underfeed stoker a number of arch and steam-jet mixing schemes have been tried, but it has usually been found that complete combustion will take place without any special mixing device if sufficient height of furnace is provided between the grates and the tubes. With chain-grate stokers an ignition arch is always provided and frequently a reverse arch over the rear end of the stoker; in some cases a third arch is added over the center of the combustion chamber in order to mix the gaseous streams coming from the three main subdivisions of the grate, and it has usually been found that better results can be obtained the more elaborate the mixing system provided. In the powdered-coal systems now in general use very little of the mixing is done in the burner. There are a number of systems which have been used in an experimental way, in which a much larger proportion of the mixing is done in the burner. With these systems it is claimed that a much smaller furnace volume will be required than is now considered necessary, and while it is hoped that the advocates of these systems will be successful in demonstrating this statement, so far they have not done so on any commercial scale.

On account of the variations in the work which the furnace has to do when used in connection with the various fuel-burning systems, it is obviously impossible to make any general comparison of the effect of furnace volume on efficiency. Consequently the effect of furnace volume must be studied separately for each of the systems. Very much more reliable test data were available on plants using underfeed stokers than with any other class of equipment, and it was found possible to plot quite a large number of tests where underfeed stokers were used in connection with 14-high Babcock & Wilcox boilers. None of these furnaces was complicated by arches or other mixing devices, thus eliminating a large number of variable elements, and while the curves show a slight tendency toward better efficiency with higher furnace volume, the information is by no means conclusive and the difference indicated may easily be accounted for by test errors or differences in skill of the operators. Furnaces having 3 or 6 cu. ft. per rated hp. cost a great deal more to build and to maintain than furnaces of smaller sizes. Personally, the author has always been an advocate of large furnaces and it would seem, judging from the results given in Table 1, that most of those who have to do with the construction of modern power plants agree with him on this point. Engineers should be in a position to prove that any extra expenditure which they make in construction or maintenance is justified by the better economies obtained.

The Construction of Boiler-Furnace Walls

In considering this subject the first two questions which present themselves are, why is a wall needed around a boiler furnace, and what are some of the more important characteristics which a perfect wall should possess? A wall is needed around a furnace to direct the heat produced by the burning fuel to the surfaces provided for absorbing it, to prevent this heat from being dissipated in all directions where it would be wasted, and to prevent excess air from entering the furnace and commingling with the products of combustion.

A perfect wall would then be one which, under all conditions of service, would be impervious to the flow of gas, air, or heat units, it would not crack, spall, or soften, and would not be injured by molten slag.

It is well known that our walls fail to meet fully the above requirements and we may profitably consider for a few moments some of the reasons for the shortcomings of present-day walls and some of the ways in which these shortcomings may be overcome.

In Table 3 are given some of the principal characteristics of refractory materials. It would seem at first glance that from this list an almost ideal combination of materials could be selected, and if cost were no object the construction of good boiler walls would be greatly simplified. Unfortunately, however, the cost of some of the more desirable materials is such as to prohibit their use except in small quantities for special purposes. Cost and distribution of raw materials make it necessary to rely on fireclay products for the bulk of our boiler-wall work.

While the firebrick themselves may fail in a number of ways (several of which ways will be discussed later), usually the weakest part of the wall is the jointing material. Up to the present time fireclay of approximately the same composition as the brick has usually been found to be the most satisfactory material with which to bond the wall, and this material is always more easily disintegrated than the firebrick. Consequently it is advisable that firebrick be obtained with as close uniformity in dimensions as possible so that the amount of jointing material may be reduced to a minimum.

Many attempts have been made to obtain a material better suited to this purpose than fireclay, and, while some of these compounds have given very satisfactory results under certain conditions, in many cases the user is paying an exorbitant price for a material having refractory qualities inferior to that of fireclay which forms the base of most of these so-called high-temperature cements. Fig. 1 shows the effect on the melting point of the mixture resulting from the addition of various materials to fireclay.

The present-day tendencies in power-plant practice are very materially increasing the severity of the conditions under which refractories are used in boiler-wall construction. These tendencies are the result of the increasing cost of fuel, labor, and equipment, which has made profitable economies in all three of these items which were not to be thought of a few years ago and may be briefly summarized as follows:

1 In order to reduce the amount of boiler equipment for a given output the rate of operation has been largely increased, bringing

about increases in furnace temperature and the area of walls exposed to high temperature.

2 Furnace walls are much tighter than formerly and are in many cases protected from radiation and air infiltration by layers of heat insulation and airtight steel casings, causing dangerous temperatures to penetrate much more deeply into the walls than was the case with the type of construction used a few years ago.

3. The reduction of excess air to a minimum and the conservation of low-level heat by preheating the air for combustion, a practice which is common in Europe and which is meeting with increasing favor in this country, will probably add several hundred degrees to present furnace temperatures.

An idea of the temperature gradient through boiler-furnace walls can be obtained from Fig. 2 which shows the temperature in the walls at the Delray station of the Detroit Edison Co. These walls are solid firebrick 28 in. thick with no insulation or steel casing. The tests were made with a slight draft inside the setting, at low ratings, the draft being increased with the rating. Considering these results, which were very accurately obtained by embedding thermocouples in the wall at various distances from the fire face,

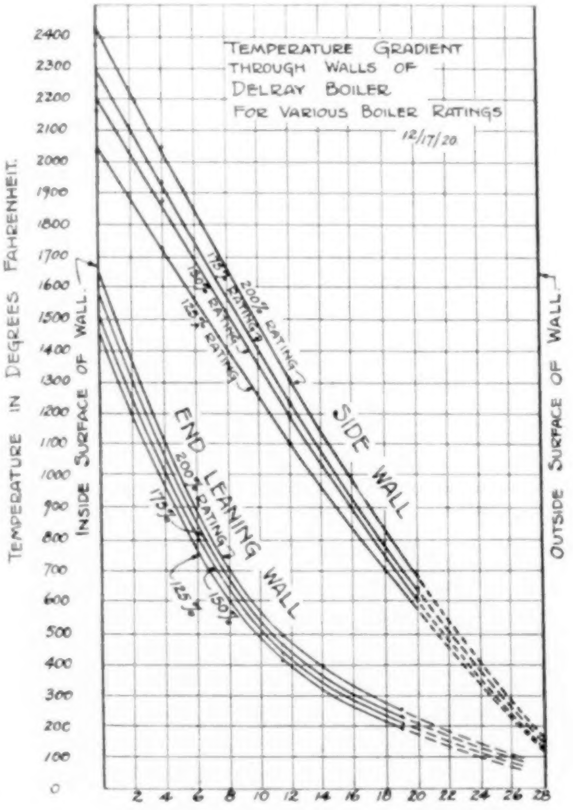

FIG. 2 TEMPERATURE GRADIENT THROUGH WALLS OF DELRAY BOILER FOR VARIOUS BOILER RATINGS

it can readily be seen that when ratings are pushed up to 400 per cent with the addition of possibly 200 deg. by air preheaters a furnace-wall temperature close to 2900 deg. fahr. will result if we continue to use the type of wall construction now generally employed.

Furnace-wall temperatures are affected to a considerable extent by the relative pressures on the two sides of the wall. This effect

TABLE 3 THERMAL PROPERTIES OF VARIOUS REFRACTORIES

Material	Fusion point, deg. fahr.	Point of failure under 50 lb. per sq. in. load, deg. fahr.	Thermal conductivity at 1832 deg. fahr., B.t.u. per hr. per deg. fahr. per inch	Specific heat at 212 deg. fahr.	Resistance to spalling
Fireclay	3092	2462–2552	11.3	0.199	Good
Silica	3092	2912	12.7	0.219	Poor
Magnesia	3929	2696	22.9	0.231	Poor
Chrome	3722	2597	16.5	...	Poor
Bauxite	3245	2462 or more	11.3	...	Good
Zirconia	4667	2750	Low	...	...
Carborundum	4064	Above 3002	67.0	0.186	Good
Alundum	3722	Above 2822	High	0.198	Good

is clearly shown by some tests made by R. M. Howe on an experimental furnace at the Mellon Institute.

The temperature of the furnace wall was measured at a point 1/2 in. back from the inside edge of the furnace under varying conditions of draft in the furnace with results as follows:

The furnace temperature was 2440 deg. fahr., with a slight draft the wall temperature was 2030 deg., with 0.05 in. pressure 2300 deg., and with 1 in. pressure it rose to 2380 deg. The importance of avoiding a positive pressure in boiler furnaces cannot be overemphasized as it is one of the most prolific causes of wall failure.

Assuming that the furnace wall has been skillfully constructed with high-grade fireclay materials, what are the principle causes of wall failure, and how may they be avoided?

As shown in Table 3, the melting point of first-class fireclay refractories is well above furnace temperatures of which there is

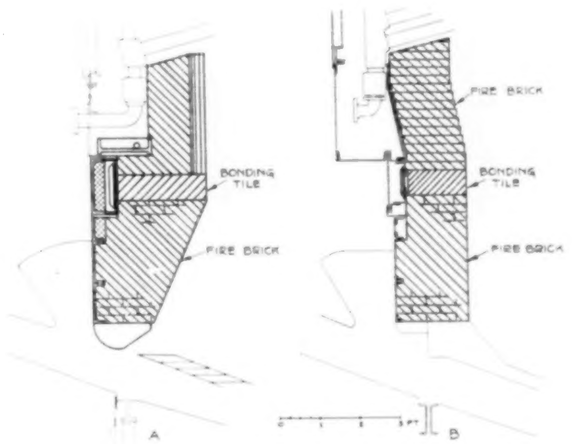

FIG. 3 (A) SECTION THROUGH FRONT WALL OF UNDERFEED STOKER THAT FAILED AFTER A FEW WEEKS' USE, AND (B) SECTION OF WALL REPLACING IT, WHICH HAS GIVEN GOOD SERVICE FOR SEVERAL YEARS

any immediate prospect; consequently, except in cases where an oil or gas flame impinges directly against the furnace wall, a condition which is usually readily remedied by the selection of suitable burner equipment, there will be little trouble from straight fusion of the furnace lining.

Again referring to Table 3, it is seen that fireclay bricks begin to soften under load at 500 to 600 deg. below their melting point. With the old-style low-set boilers this was not a very important feature because the surface exposed to high temperatures was small and the superimposed loads light. With modern high-set boilers, however, this characteristic of firebrick has assumed increasing importance. The liability to failure from this cause is a function of the depth of penetration in the wall of a temperature which would cause softening and of the shape of the wall. A study of Fig. 3 will show what is meant by the latter statement. To the left is shown the front wall of an underfeed stoker setting which is corbeled in such a way as to impose a very heavy load on the course of brick just above the ram-box caps. It will be readily seen that a slight softening of the lower rows of brick will cause the whole front wall to fall into the furnace. The life of this wall was only a few weeks and it has been replaced by the one on the right which has given several years' service with no trouble.

A study of a large number of reports on the life history of walls all over the country has indicated that the wall which leans in toward the furnace is a constant source of trouble.

The erosion of firebrick by molten ash is responsible for more furnace-wall failures than all the other causes put together. Where coals are used having a high ash-fusion temperature, say 2700 to 2800 deg. fahr., ash erosion is not important; but such coals are scarce now and are becoming more so every day, and furnaces must be so constructed that they will function successfully with coals the ash of which begins to soften at 2100 deg. and runs at 2300 deg.

The effect of ash erosion is most pronounced where a pulverized-coal or forced-draft-stoker flame strikes the furnace wall. These flames carry small particles of molten ash which penetrate any cracks or pores in the brickwork. The surface of the wall then

becomes a mixture of firebrick and ash, which has a melting point much lower than firebrick.

Coal ash is not a definite chemical compound but a mixture of many compounds. It consequently has no definite melting point like ice but changes state gradually, there frequently being an interval of 200 to 300 deg. between the first signs of softening and the point where the viscosity has been so reduced that it will readily flow.

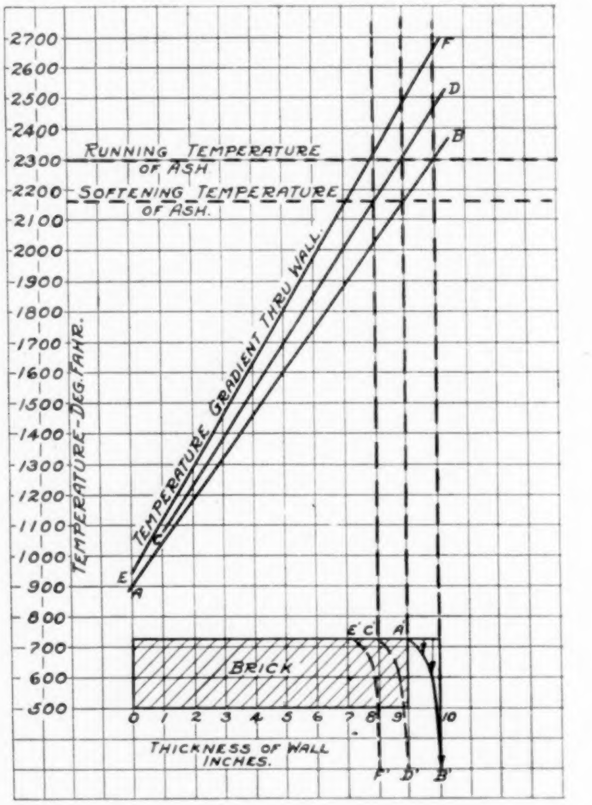

Fig. 4 Manner in Which Erosion of Furnace-Wall Firebrick by Molten Ash Takes Place

Ash erosion is a function of the depth of penetration of the ash-flow temperature into the furnace lining, the porosity of the wall, and the relative composition of the refractory and the ash with which it comes in contact. The manner in which this erosion takes place is well illustrated in Fig. 4, for which diagram and the explanation following the author is indebted to an article by Henry Kreisinger in the 1922 Prime Movers Committee report.

If the surface of the furnace lining is below the running temperature of the ash, the molten ash coming in contact with it is cooled to the temperature of the brick and becomes a thick, viscous fluid adhering to the brick and moving slowly over the surface. Owing to its high viscosity the ash does not penetrate into the brick and will not wash it away, but forms a pasty coating over the surface of the brick. The thickness of this coating depends on the interval between the softening temperature and the running temperature of the ash, and on the rate at which heat passes through the layer of pasty ash and the brick. The surface of the coating away from the brick is at the running temperature, and any further deposit of molten ash will run down over the coating without harming the brick. This condition is shown in Fig. 4 by the temperature gradient *AB*. The length of the arrows near the surface of the brick indicates the speed at which the various layers of the coating of the ash move. The heads of the arrows form a curve *A′B′*.

If the surface of the brick is at the temperature of the running ash, the ash penetrates to a small extent into the brick and the abrasion of the furnace lining begins. This condition is illustrated by the temperature gradient *CD*. The curve of the moving slag is shown by the dotted line *C′D′*.

A temperature condition very destructive to the brick lining is shown by the gradient *EF*. The temperature of the running ash is one inch within the brick and the molten ash penetrates into the brick rapidly and washes the brick away.

The depth of penetration of dangerous temperature in furnace walls with a given furnace temperature is largely influenced by the material of which the wall is constructed, its thickness, and the velocity of air currents against the outside of the wall.

The effect of these items is shown in Fig. 5. In preparing this diagram it was assumed that the furnace was operated in such a manner as to maintain a temperature of 2500 deg. fahr. at the inner edge of the wall; that the coal burned has an ash-softening point of 2100 deg. and the ash flows at 2300 deg. fahr. To the left of the figure are shown various wall thicknesses of solid firebrick. In the center are walls composed of a combination of firebrick and insulating material which is assumed to have one-tenth the heat conductivity of firebrick, and on the right is illustrated the hollow-wall construction, where the air for combustion absorbs the heat radiated through comparatively thin walls. A study of these diagrams shows clearly the danger of using insulation in furnace walls where the walls are not provided with any cooling arrangement, and the advantage which results from employing the hollow ventilated wall construction where high combustion temperatures are being dealt with.

If we would obtain the highest efficiency coupled with long wall life, the walls must be so constructed that air cannot leak into the furnace and a minimum of heat will be radiated from the walls. This must be done while burning the fuel with a mininum of excess air which has been preheated several hundred degrees; and it is obvious that walls made of fireclay brick will not stand such punishment unless some means are provided for reducing the wall temperature relative to the combustion temperature in the furnace.

In the Lopulco system of burning pulverized coal a combination of air and water cooling of furnace walls has worked out very satisfactorily. This system of cooling the walls by heating air for combustion is well suited to conditions where it is desireable to introduce a large part of the air for combustion as secondary air, but would not be very desirable in combustion systems where all or a large part of the air is primary air, such as stokers, mechanical atomizer oil burners, and certain powdered-coal systems. Another difficulty with air-cooled walls is that it makes it more difficult to use low-level heat which is available at slight expense for preheating combustion air.

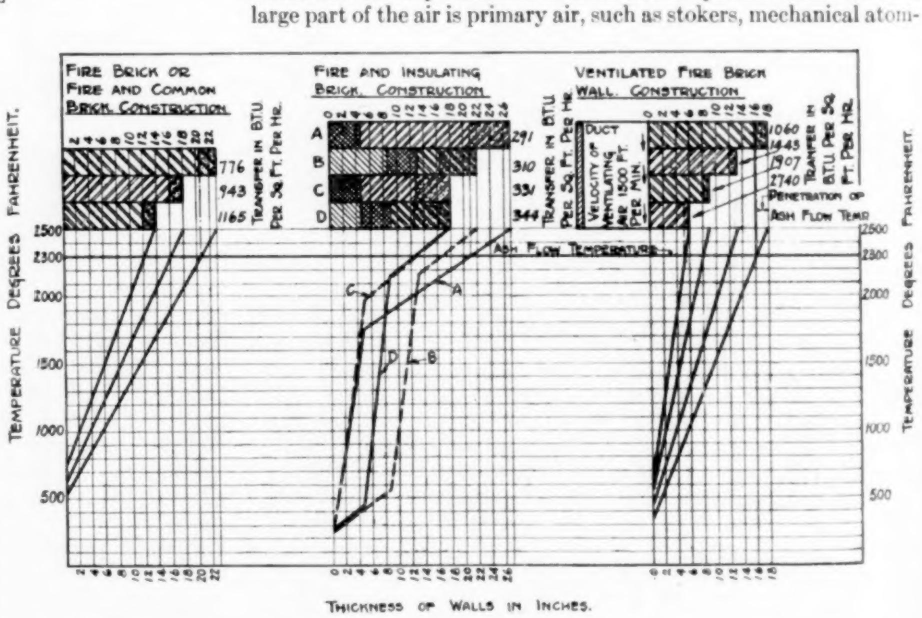

Fig. 5 Effect of Type of Furnace-Wall Construction on Penetration of Dangerous Temperatures into Brickwork

In the author's opinion the present tendency of boiler-furnace design is toward a furnace in which combustion will take place entirely surrounded by water- and steam-cooling surfaces.

Discussion

Mr. Ricketts' paper was presented on March 27 at a meeting of the Metropolitan Section of The American Society of Mechanical Engineers, and for helpful discussion and sustained interest the session was one of the best ever held under the auspices of that section. Kingsley L. Martin, chairman of the Fuels Committee of the Section, presided.

In presenting his paper Mr. Ricketts gave the following additional ratios of cubic feet of furnace volume to rated boiler hp.,

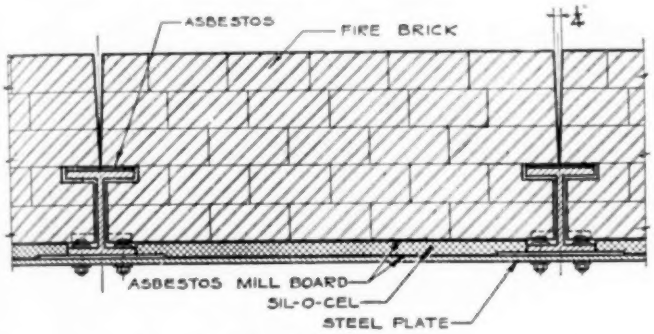

Fig. 1 Plan of Furnace Wall at Hell Gate Station, United Electric Light & Power Co.
(The tapering expansion joint closes when the boiler is in service.)

these representing furnace design of plants built some years ago:

	Cu. ft. per rated boiler hp.
Waterside Station, New York Edison Company	1.05
Essex Station, Public Service of New Jersey	1.95
Dodge Bros.,' Mishawaka, Ind.	2.17
Muscle Shoals	2.17
Connors Creek, Detroit Edison Co.	2.75
L. Street, Boston	2.93
Springdale Plant, Pennsylvania Power Co.	2.95

The discussion was opened by V. M. Frost[1] who emphasized the desirability from an overall economic standpoint of using ordinary, first-quality brick in furnace construction, rather than the more expensive so-called "super-refractory" brick; also the desirability of obtaining from the brick manufacturers a more uniform product, true to shape and dimensions, which would very materially assist in obtaining better service and longer life from the common refractories.

He also outlined the possibilities of the use of air-cooled walls as a means of securing better service from the ordinary brick, which would stand up better under compression loads if the heat of the furnace did not penetrate too deeply, as indicated in Mr. Ricketts' paper.

In his work Mr. Frost used the ratio of combustion volume to heating surface, and stated that he had found a value of 0.4 to 0.5 to be a satisfactory one for this ratio. In a furnace designed on this basis under a boiler of 3000 sq. ft. of heating surface, over 2000 lb. of coal per hour had been burned, without slagging or melting of the brick.

John H. Lawrence[2] presented a sketch, Fig. 1, showing the method of constructing the walls of the Hell Gate Station by which the strain on the wall was reduced and expansion provided for. Mr. Lawrence pointed out that a particular trouble in brickwork maintenance was caused by erosion of the front wall just above the stoker.

E. S. Cooley[3] told of the recent realization on the part of paper manufacturers of the importance of fuel saving. The steam plant of the paper mill must furnish steam at 90 lb. to cook the wood and at 15 lb. pressure to dry paper. In a large paper mill there was a remarkable opportunity for economy in fuel. In the design of furnaces Mr. Cooley emphasized the importance of making proper allowances for expansion and contraction. He had successfully used an expansion joint of asbestos millboard. He also told of his experience in installing oil burners under low-set boilers and of securing high efficiencies by allowing the entire lower sets of tubes to be exposed to the flame.

C. G. Spencer[4] commented on Fig. 1 of Mr. Ricketts' paper and stated that in considering the ratio of furnace capacity to boiler horsepower the characteristics of the fuel must be kept clearly in mind. At the Cahokia plant, which had the large ratio of 6.05 cu. ft. per rated hp., the coal used had a long flame of from 50 to 60 ft., the temperature of the ash was 2000 deg. fahr., and the coal had a sulphur content of 5 per cent and an iron content of 18 per cent. Mr. Spencer also stated that it was his belief that an air-cooled wall would give the longest life. He described an economical method of repairing side walls in which a ganister of refractory material was applied with a cement gun.

A. W. Patterson[5] discussed a number of drawings which he had

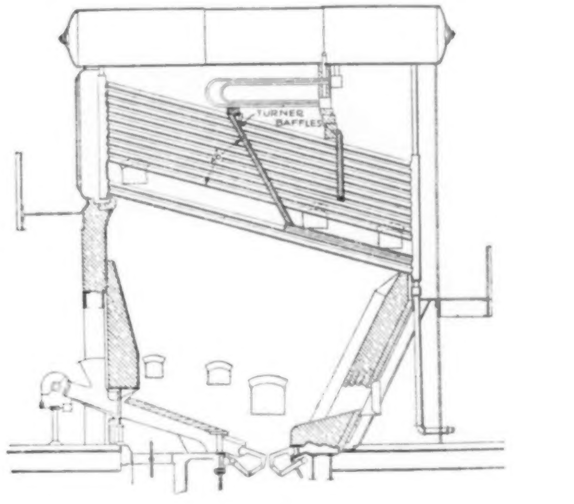

Fig. 2

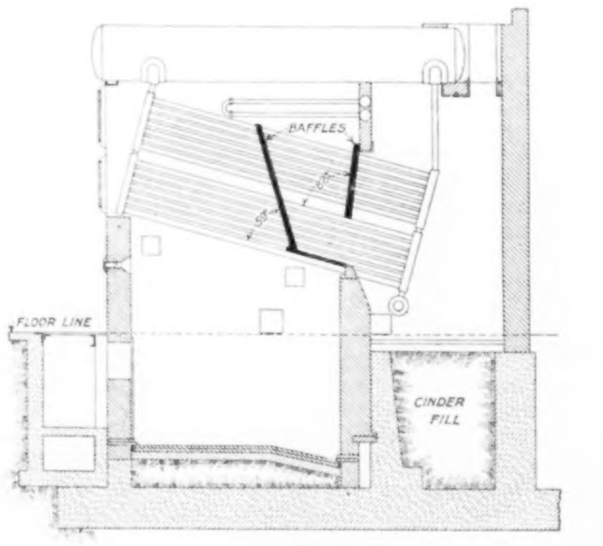

Fig. 3

projected on the screen and which were taken from existing installations, the purpose being to illustrate the possibilities of harmonizing baffle and furnace design to secure long life for the furnace and low maintenance costs. In the first, a vertical baffle, the bottom of which was connected with the bridge wall by means of a flat shelf, was replaced by an inclined one similar to that shown in Fig. 4, with the lower end resting on the bridge wall. In the second the baffling was arranged roughly like that of Fig. 2. In both cases the baffle was laid out on the principle of exposing additional heating surface to the radiant heat of the furnace, thereby lowering somewhat the furnace temperature and absorbing heat

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[2] Engineering Manager, Thos. E. Murray, Inc., New York, N. Y. Mem. A.S.M.E.

[3] Inspector Steam Plants, International Paper Co., New York, N. Y. Mem. A.S.M.E.

[4] Mechanical Engineer, McClellan & Junkersfeld, New York, N. Y. Mem. A.S.M.E.

[5] Vice-Pres., The Engineer Co., New York, N. Y. Mem. A.S.M.E.

which would otherwise have to be taken up by the brickwork. Also the lower velocities due to increased opening in the entrance to the first pass decreased the possibilities of slag and a tendency toward positive pressure in the furnace.

The setting shown in Fig. 2 was used on eight 1000-hp. and six 750-hp. boilers with underfeed stokers. The bridge wall and back wall were one with a backward slope. This gave rigidity and a reflecting surface throwing the heat out of the furnace against the tubes. The front wall was built in two separate parts, one under the header and the other from the stoker up. This relieved the brickwork of weight and the backward slope of the protecting wall added to rigidity. The entire roof of the furnace was heat-absorbing; the entering velocity in the first pass was low. These boilers had been in operation for a number of years with excellent operating efficiency and low maintenance.

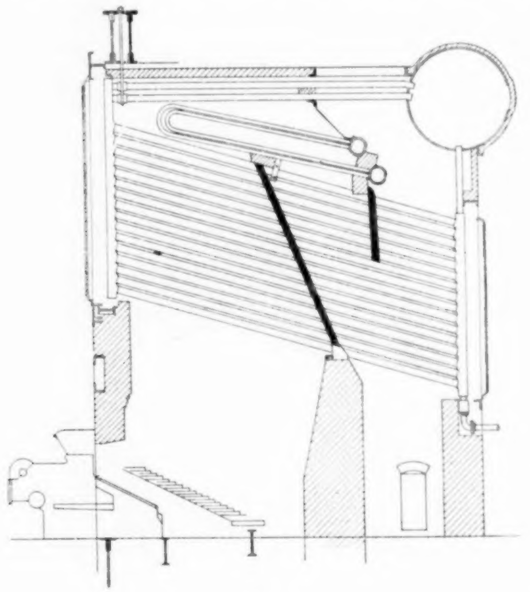


Fig. 4

Fig. 3 showed the solution of a furnace problem for low-set boilers in connection with the application of oil burning. The higher ratings made necessary a considerable furnace volume; also height and depth. It was learned that the foundations were in excellent condition and were so built that the furnaces could be installed in the foundations. This was done by the proper use of insulating materials combined with firebrick. It was noted that the bridge wall was supported by a concrete pier. The sidewalls had protecting piers of insulating material and firebrick. The baffle design was made to conform to the furnace by a combination of a flat shelf and inclined front baffle, the design being such that a suitable soot pocket could be secured behind the bridge wall.

The boiler shown in Fig. 4 had a builder's rating of 1500 hp. and was installed in the Middle West. A considerable amount of slagging in the lower rows of tubes occurred due to the character of coal available. This slag caused a tendency toward positive pressure in the furnace and trouble was experienced in maintaining the front wall. The baffles were accordingly redesigned as shown in Fig. 4, increasing the entrance to the first pass about 50 per cent and changing the rear baffle to prevent restriction of gases in passing through; a slight backward corbeling was also given to the bridge wall to provide rigidity of the bridge wall and to conform to the new baffle location. Originally the front baffle was vertical, dropping from the top point of the present inclined baffle. At its lower end the old baffle was connected by a baffle following the tubes to the vertical bridge wall which occupied nearly the position of the present one.

These changes, which reduced the velocity of the gas entering the first pass, and possibly the somewhat lower furnace temperature, entirely eliminated slagging, which in turn prevented the occurrence of positive pressure and materially increased the life of the brickwork. It was also found that the stoker repairs were somewhat reduced and that possibly a somewhat lower flue-gas temperature resulted. During the past twelve months (the second year's operation), this boiler was on the line 86 per cent of the time as compared with about 70 per cent average time of the other boilers in this plant. The total cost of maintenance of boiler, furnace and stokers was about one-third the average for about five other boilers in the plant.

Other drawings shown by Mr. Patterson were front and side elevations of a 1000-hp. boiler, in the brickwork of which the use of molded blocks was carried out quite completely, the blocks being 6 by 6 by 18 in. The jointing was reduced about 30 per cent as compared with ordinary firebrick, and the larger size, it was thought, formed a better bond with the outside walls. The furnaces were made with an air space and cast-iron ties were inserted to form an additional bond between the inside and outside sections of the wall. The side walls were supported with relieving arches. The front wall under the header was of the suspended-arch type. Perforated blocks were used along the clinker line of the bridge wall.

The boilers shown in Fig. 5 were of approximately 1600 hp. each. The original baffling arrangement was such that positive pressure occurred and there was considerable brickwork maintenance. The baffles were redesigned, securing lower velocities at the entrance to the first pass and a lower draft drop through the entire furnace. This change eliminated the slag and positive-pressure condition and reduced brickwork maintenance. It was interesting to note the funnel shape of furnace, both front and rear walls being inclined, giving additional rigidity.

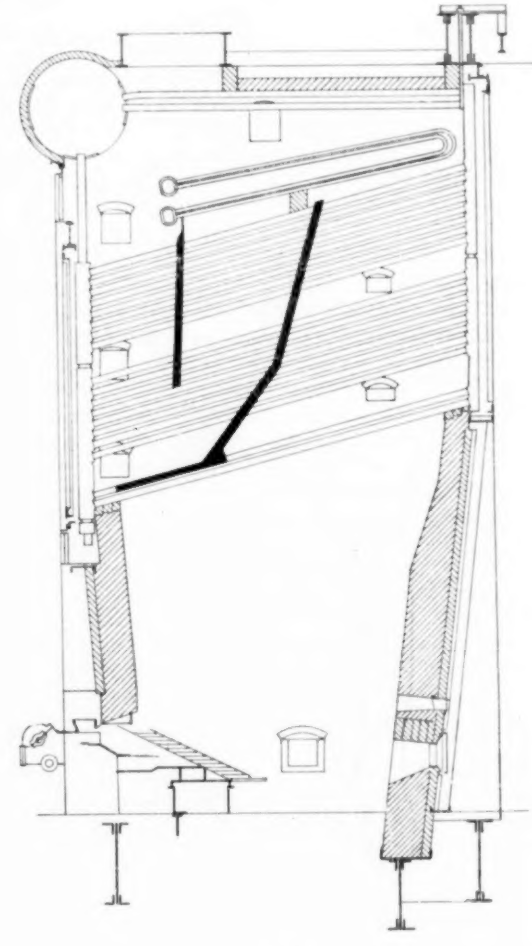


Fig. 5

The principles involved were the same for boilers operating with powdered coal.

Other discussions were submitted by George Bell, T. B. Stillman, H. D. Savage, E. Wise Sayer, and A. A. Adler. The last mentioned pointed to the excellent results attained in Scotch marine and locomotive boilers where the firebox is surrounded by heating surfaces.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

The Generation and Utilization of Cold

A GENERAL discussion on the generation and utilization of cold was held jointly by the Faraday Society and the British Cold Storage and Ice Association on October 16, 1922. The subject was treated under two headings, namely, laboratory and industrial methods of liquefaction, and practical applications of low temperatures. The subjects discussed belong particularly to the region of low temperatures such as are involved in the liquefaction of gases rather than that of medium temperatures as used in ice making and the like.

Prof. J. Kamerlingh Onnes of the Leyden cryogenic laboratory spoke of the lowest temperature yet attained. He gave a brief history of the efforts made in the liquefaction of helium, together with a description of apparatus employed. In this work, it may be mentioned, he was assisted by a gift of helium from the United States Navy. With the apparatus recently developed considerable amounts of liquid helium can be obtained and the author describes in full the apparatus and precautions used. With this it is believed that the lowest temperature obtained is below 0.9 deg. K., and the question whether it would be possible to descend below 1 deg. K. is thus answered positively. If it had been possible to have gone further only one-sixth of a degree, the limit obtainable in the ordinary way with helium would have been reached.

The apparatus and methods in the Leyden cryogenic laboratory are described in a paper with this title by C. A. Crommelin. The purpose of the laboratory is and has always been to be able to produce any temperature below 0 deg. in order to be able to make accurate physical measurements at these temperatures. And the claim is, for accurate measurements at least, a constancy of 0.01 deg. during several hours. The best way to fulfil this claim is to make use of liquefied gases boiling, well stirred, under different pressures and keeping these pressures exactly constant. In Leyden only pressures of one atmosphere and lower (often as low as a few millimeters, and in the case of helium a few tenths of a millimeter) are used, as the construction of cryostats for considerably higher pressures than one atmosphere is difficult and may even present danger. The region of temperatures covered by each substance is therefore the region between the boiling point and its triple point.

The article describes in some detail the liquefaction of air, the hydrogen plant, the liquefaction of helium, the liquefaction and purification of neon, and the various cryostats used at the laboratory.

Prof. C. F. Jenkin presented a paper on ethyl chloride, containing among other things a pressure-temperature curve, and stated that he is carrying out a complete investigation of the thermal properties of this fluid and that complete θ-ϕ and I-ϕ charts will shortly be published.

In the discussion which followed Prof. A. W. Porter suggested a new method for obtaining a truer extrapolation in determining the extremely low temperatures, using for this purpose one of the various theoretical curves which are adopted for representing vapor pressures.

The next group of papers dealt with industrial methods of liquefaction and practical applications of low temperatures. This group started with a semi-historical paper by K. S. Murray on industrial methods of liquefaction, dealing largely with the history of the British Oxygen Company. It also described the features of the Claude and the Linde processes, and referred briefly to the Norton process.

The manufacture of hydrogen by the partial liquefaction of water gas and coke-oven gas was described by Georges Claude. In this process water gas compressed to a suitable degree is in the first instance deprived of its carbon dioxide and moisture. It is then sent into a heat exchanger in which it is cooled by circulating in the opposite direction to the hydrogen and carbon monoxide which have already been separated. The gas then enters the bottom of a sheaf of vertical tubes, the lower portion of which plunges into a bath of carbon monoxide boiling under atmospheric pressure. By the combined influence of the pressure and of the temperature of the liquid bath a large portion of the carbon monoxide of the ascending gases is liquefied and flows back into a collector located below the vertical tubes. This liquid is forced into a vaporizer where it replaces the liquid which is being evaporated. The remaining gas containing hydrogen and a little of the residual carbon monoxide continues to rise in the sheaf of vertical tubes, where it encounters a temperature which is being more and more lowered by special means. Under that influence the remainder of the carbon monoxide is liquefied and the hydrogen, which theoretically ought to be sensibly pure, escapes.

In working this process two sources of inconvenience were encountered. In the first instance when the hydrogen is entering the expansion engine at extremely low temperature the frigorific efficiency of the expansion is very low, in addition to which there is an abnormal friction in the engine which still further lowers the frigorific efficiency. In the second place, the calorific mass of the gases leaving the tubes and circulating about the rising gases is smaller than the mass of the latter by the entire amount of the carbon monoxide which has been liquefied by their action. As a consequence, the ascending gas cannot, even assuming a perfect heat exchange to take place, leave the sheaf of tubes at the temperature at which the expanded gases enter the tube. The author describes how these and other troubles have been overcome in practice. The process has been developed and put into practice in a plant at Grande Paroisse, France, where an apparatus for the production of 500 cu. m. of hydrogen per hour is in operation, feeding a unit for five tons of ammonia per day.

The author mentions also that he has already successfully tried an apparatus where hydrogen is produced from coke-oven gas, which is of importance because it permits the recovery of by-products which are lost now.

Edgar A. Griffiths discusses in detail the production of liquid oxygen for use on aircraft, in particular for high-altitude flying. Of interest in this same connection is the paper by A. J. Bremner describing the Heylandt liquid-air plant, as this was intended to supply oxygen for use with the "Aerophor" liquid-air self-contained breathing apparatus.

The paper by Cosmo Johns deals with another application of oxygen, namely, that of enriching air supplied to metallurgical furnaces, such as copper-smelting, blast furnaces, open-hearth, bessemer, etc. In this connection the author calls attention to the fact that it is not pure oxygen that is required, as it would be amply sufficient if the oxygen content varied between the range of 20 and 40 per cent. What is required, however, is not pure oxygen in steel bottles but enriched air in hundreds of tons, as the production of one ton of pig iron requires 140,000 cu. ft. of air at normal temperature and pressure.

Attention is also called to the papers, Thermometric Lag with Special Reference to Cold Storage Practice, by Ezer Griffiths and J. H. Awbery, Some Materials of Low Thermal Conductivity, by Ezer Griffiths, and A Note on the Importance of the Study of the Crystal Structure and Properties of Metals at Low Temperatures, by Cosmo Johns.

In the discussion which followed Dr. J. A. Harker called attention to a fact which may be of considerable importance, namely, that in four or five different plants which he had visited, working on the Claude process where expansion engines were in use, he had noticed in almost every instance that the energy recovered was turned into a resistance coil and accomplished no useful purpose,

except possibly that of warming the room. It was never used as it was figured in the textbooks and turned into the line to diminish the power requirements in the way that theoretical people talk about.

H. Brier told about an experiment which was made about 1890 with enriched air on a small bessemer converter in Glasgow. Oxygen was then introduced in different percentages into the air blast. At no time was any great quantity of oxygen used, but the results were most disastrous. After a very short time the tuyeres and bottom of the converter were consumed and blew out, and those in attendance very naturally stood away from the converter expecting the charge to follow; but only a moderate flow of liquid came out into the bottom of the pit, and this was found to be the liquid formed by the melting of the tuyeres and lining, all combustible metal having disappeared, leaving only a black skull in the top of the converter.

Cosmo Johns, in dealing with the question of enriched air stated that it was the increase in the partial pressure of the oxygen that was the really significant factor in the use of oxygen-enriched air. The available evidence strongly supported the view that variations in the concentration or partial pressure of the oxygen would alter the order in which the metals and metalloids were oxidized in the bessemer process for basic-steel making.

Dr. Richard Linde, in dealing with the development of the oxygen and nitrogen industries in Germany, gave the following figures: At present more than 2,500,000 cu. m. (nearly 100,000,000 cu. ft.) of oxygen are put upon the German market every month, in steel cylinders. In addition, a large number of engineering works and shipbuilding wharves make their own oxygen for autogenous metal working, and that oxygen production may be estimated at 1,000,000 cu. m. per month. Finally, the chemical industries require very considerable amounts of oxygen which the works likewise generate in their own plants; this oxygen will also exceed 1,000,000 cu. m. per month. Thus Germany is at present producing at least 50,000,000 cu. m. (1,750,000,000 cu. ft.) of oxygen per year.

The amount of nitrogen produced by the liquefaction of air and utilized almost exclusively for the manufacture of fertilizers is considerably larger, Dr. Linde estimating the annual German demand for nitrogen at 300,000,000 cu. m. (more than 10,000,000,000 cu. ft.). (*Transactions of the Faraday Society*, vol. 18, pt. 2, no. 53, Dec., 1922, pp. 139–273, illustrated, *tdA*)

Short Abstracts of the Month

AERONAUTICS (See also Internal-Combustion Engineering)

Marcel Besson H-5 Quadruplane Flying Boat. It is stated that this machine has recently been successfully tried out in France. The problem was to design one that would, without being too cumbersome, be capable of carrying heavy loads and a large number of passengers, as many as twenty. This problem was solved by arranging the planes in quadruple form, one pair close behind the other, and each pair stepped and staggered in relation to the other. Interference between the forward and rear pairs of planes was expected, but the trial flights demonstrated that there was little or none of it.

The main planes are of comparatively thick section and have a high aspect ratio. The upper and third planes are located a little less than the chord width in advance of the second and bottom planes. Each pair of planes has an arrangement of X interplane struts, while struts also connect the rear spars of the forward planes to the front spars of the rear planes. The whole wing cellule is divided into three bays on each side. The arrangement of struts enables the wire bracing to be reduced to a minimum. The lowermost plane is set at a dihedral angle—about $1^1/_2$ deg. Ailerons are fitted to all four planes; these ailerons, it will be seen, are long and narrow, and although their individual effectiveness may be slight, their combined action should give ample control.

One advantage claimed for the grouping of the main planes as adopted by M. Besson is that the travel of the center of pressure for each plane is small, and therefore the total c. p. travel is also small, whereas this would be much greater if only two planes, giving the same combined total area, were employed. Consequently it is said that, for a large machine, this arrangement makes for easier piloting.

The tail group of the Besson quadruplane is also interesting. It consists of two horizontal and three vertical surfaces. Of the former, the upper and smaller is used as an elevator only, while the lower and larger surface (of 26 ft. 3 in. span) serves as a stabilizer and has an auxiliary "elevator" for adjusting the incidence for longitudinal trimming. The three vertical surfaces comprise a central triangular fin, to the trailing edge of which is hinged a rudder and two similar but smaller units mounted one on each side of the central one. The hinged flaps on these outer surfaces are normally in neutral position but may be adjusted at the will of the pilot for the purpose of trimming the machine should the failure or fall in power of one or other of the engines necessitate this.

The engines at present fitted are four 250-hp. Salmsons. During the tests the machine, which weighs fully loaded just over 10 tons, took off a run of some 500 yd. and attained a speed of 81 m.p.h. with full load. (*Flight*, vol. 15, no. 7/738, Feb. 15, 1923, pp. 89–90, 2 figs., *d*)

AIR MACHINERY

Formula for the Rate of Exhaustion of a Large Tank by a Reciprocating Air Pump, E. Buckingham. The conditions for the validity of the formula are as follows: (1) The piston and the valves do not leak; (2) there is no appreciable throttling except at the valves; (3) the volume to be exhausted is very large in comparison with the piston displacement; (4) the temperature of the air in the tank is constant; (5) the temperature in the pump at the end of any suction stroke is constant; (6) the pump discharges to atmospheric pressure, and the air in the tank starts at atmospheric pressure.

Let P = atmospheric pressure
N = number of completed pump cycles
p = pressure in tank after N cycles
x = p/P = degree of exhaustion
l = limiting or lowest attainable value of x
a = fraction of 1 atmosphere required to lift the discharge valve
b = fraction of 1 atmosphere required to lift the intake valve
c = ratio of clearance to piston displacement
t = ratio of absolute temperature in the pump at the end of a suction stroke to absolute temperature in the tank
v = ratio of volume of tank to piston displacement
n = exponent in the equation of the compression line, pv^n = constant

In any one problem the last six quantities are pure numbers and independent of the units used. a, b, and c are always small; if the valves are operated positively, $a = b = 0$; if the pump is oil-sealed, $c = 0$. The temperature ratio t never differs much from unity. The volume ratio v is supposed to be large. The exponent n is between 1.0 and 1.4.

The formulas obtained are:

$$N = A \log_{10} \frac{C}{(x-b)^{1/n} - B}$$

and

$$l = B^n + b$$

where

$$A = \frac{2.303\ ntv}{1+c}$$

$$B = \frac{c}{1+c}(1+a)^{1/n}$$

$$C = (1-b)^{1/n} - B$$

(Abstract of *Technologic Paper of the Bureau of Standards*, No. 224, *e*)

BUREAU OF MINES (See Corrosion)

BUREAU OF STANDARDS (See Air Machinery)

CORROSION

Corrosion Tests of Metals in Mine Waters. The results of corrosion tests on 45 different metals and alloys in acid mine waters from coal mines, made in the course of a coöperative investigation by the Carnegie Institute of Technology, the United States Bureau of Mines, and an advisory board of coal-mining engineers, are summarized in Bulletin 4 of the Coal-Mining Investigations series, just published by the Carnegie Institute of Technology, Pittsburgh, Pa.

Water from coal mines is usually decidedly acid in character, and causes considerable trouble and expense owing to its corrosive action on mine equipment. These waters contain free sulphuric acid, and ferrous, ferric, and aluminum sulphates, in addition to sulphates of calcium, magnesium, sodium, and potassium, together with silica, and usually some chlorides. On standing, dilution, aeration, or warming, insoluble iron compounds tend to precipitate, principally as hydrous ferric oxides. The occurrence of iron sulphates and free sulphuric acid is due to the action of water and air on the pyrite or marcasite associated with the coal. These substances are oxidized to ferrous sulphate, ferric sulphate, and sulphuric acid.

In the coöperative investigation made by the Bureau of Mines and the Carnegie Institute of Technology three test specimens of each of the 45 metals and alloys were completely immersed in flowing water at each of three coal mines in western Pennsylvania for periods ranging from 98 to 135 days. The waters from these mines covered a wide range of acidity, from one esteemed to be below the average of that region to a water which is considered to be extremely acid. Inspections were made at regular intervals, and the degree and nature of corrosion was noted. At the completion of the test the specimens were removed, cleaned, and the extent and nature of the corrosion recorded. Samples of the mine waters were collected at each inspection, and the degree of acidity determined. Complete analyses were also made on the waters from the three mines.

All alloys tested of the brass type, containing considerable zinc, were corroded extensively by the mine waters. Bronzes, containing considerable tin, were also corroded, but to a less extent than the brasses. Evidently copper-zinc alloys are less desirable for use in mine water than copper-tin alloys.

Cupro-nickel alloys were corroded about to the same amount as the brasses. Nickel-silver alloys, which contain copper, zinc, and nickel, were also corroded extensively. Aluminum alloys showed a marked tendency to pronounced pitting.

The materials which showed a marked resistance to the corrosive action of the acid mine waters include a high-chromium steel, two highly alloyed chromium-nickel-silicon steels, a high-silicon cast iron, and a nickel-chromium-iron alloy. All of these materials, except the high-silicon cast iron, contain large amounts of chromium. These resistant materials have certain disadvantages for general use in coal-mine equipment, such as the brittleness and hardness of the high-silicon cast iron and the relatively high cost of the others; however, these resistant materials should prove satisfactory for use in pump parts and other equipment where these factors are not a serious consideration.

Economic considerations, such as cost, ease of fabrication, and physical properties, will be factors in determining the suitability of a metal or alloy for use in equipment exposed to the action of acid mine water. (Abstract from Bulletin 4 of the *U. S. Bureau of Mines*, by W. A. Selvig and George M. Enos, *ep*)

ENGINEERING MATERIALS (See also Corrosion)

Aluminizing Iron Articles. The following is quoted from the Notes and Memoranda column of a recent issue of *The Engineer*, which does not, however, give the source of the information.

"Articles made of a 15 per cent aluminum-iron alloy develop, on being heated to redness, a thin but highly resistant surface layer of aluminum oxide which does not scale, and prevents further oxidation of the metal, so that no appreciable alteration of the surface is noticeable after heating at a high temperature for one hour in a strongly oxidizing atmosphere. The alloy gives good castings and may, with care, be forged. Similar results are obtained by treating soft-iron articles by the Alitier process, which consists in heating the metal for some time, surrounded by a powder containing aluminum, whereby the latter penetrates the surface of the iron for a certain distance and forms a surface layer of iron-aluminum alloy that behaves in a similar manner to the 15 per cent alloy described above. An iron crucible treated by this method was practically unattacked after heating to 1000 deg. cent. for sixty hours, whereas a similar untreated crucible was destroyed in twenty-four hours." (*The Engineer*, vol. 135, no. 3500, Jan. 26, 1923, p. 93, *g*; cp. the process known in America as "calorizing.")

Condenser Tubes—Manufacture and Specifications

Condenser Tubes, Their Manufacture and Specifications, Technical Staff of the Chase Metal Works, Waterbury, Conn. An interesting description of the general process of manufacture, with special reference to Admiralty brass tubing and including a discussion of the causes of condenser failures.

The authors endorse the change recommended by Committee B-2 of the American Society for Testing Materials, i.e., that the minimum percentage of tin in the Admiralty mixture be decreased from 1 per cent to 0.9 per cent. This change was recommended in order that manufacturers might keep the average tin content as closely as possible to 1 per cent, which seems to be the ideal proportion for this mixture. This the authors feel to be an advantage and recommend the proposed change.

As regards the question of grain size, it is stated that the last drawing and annealing operations determine the final grain size of Admiralty condenser tubes within the usual tolerances.

To prove this statement the following test was made: A tube was picked at random from a pile of tubes that had just received the last but one drawing operation. This tube was cut off, one-half was annealed at a low temperature which gave a fairly small grain size, the other half was annealed at a high temperature which gave a larger grain size. Both these tubes were given the usual final drawing operation and afterward cut into lengths and given different annealing treatments. Although the annealing tests were made with tubes that had widely different grain size to start with, still the final grain size was in no case greater than 0.025 mm. This proves that the last drawing operation and the last anneal are sufficient to control the final grain size of a condenser tube within the usual tolerances.

These and many other tests of a similar nature show (1) that the final drawing and annealing are sufficient to control the final grain size within the usual tolerances, and (2) that the final grain size is absolutely determined by the last two drawing operations and the last two anneals.

This is also the opinion of the U. S. Naval Engineering Experiment Station at Annapolis, Md., which states that, in their experts' opinion, differences of method in the early stages of production, such as the casting process, have no bearing upon the grain size of the finished tube, and that the latter stages of production (drawing and annealing) are the controlling factors.

Entirely separate from the question of the production of such fine grains is the question of their desirability. The authors' search of the technical literature, the results of laboratory experiments, and the examination of failed condenser tubes have disclosed no evidence whatever that a tube of any particular grain size will last longer than a tube of any other particular grain size, other things being equal. It must be clearly understood that grain size is only a measurement of the annealing of temper of a metal. The temper of a finished condenser tube should necessarily fall between certain limits, but by diminishing the size of the grains a point is finally reached where there is a real objection to too fine a grain-size requirement, because in order to produce exceedingly fine grains it is necessary in the final operations to draw the material very hard, preceded preferably by relatively light anneals. This means an increased wear on the dies, an increased tendency toward scratching, and increased difficulty in getting narrow dimensional tolerances. All these things increase the cost of manufacture, for which the user will have to pay and for which he gets no return in increased life of the tube in service.

While a certain range in grain sizes may be desirable, it does not seem advisable to specify a definite size or maximum limits on

grain size and to lay such stress on the necessity of having tubes meet this requirement. This is specially true when it is considered that the determination of grain size in alpha brass is itself a relatively inaccurate measurement where errors of 10 to 20 per cent are common.

The real progress in condenser-tube manufacture has not been in discarding the cast-shell process but in the improvement of that process itself. Within recent years a large amount of research has been done in this connection and great progress has been made in the art of casting shells on a core. At the Chase Metal Works this research has resulted in the development of a special sand core, a special core dressing, and a method of casting by which cast shells are produced absolutely clean and sound. This improvement in the core and core dressing makes a tube as clean on the inside as it is on the outside; in fact, this improved core gives a satin finish and smoothness on the inside surface that the iron mold will not always produce on the outside surface.

In the same way that the grain size of the finished tube is shown to be produced by the last two drawing and annealing operations only, it may be proved that all the physical properties, including the ability to withstand the hammer, pin, and compression test, are likewise determined by the same two operations.

It is obvious from the above that a sound condenser tube can be made to comply with any reasonable specifications, irrespective of its casting or early stages of manufacture, by the annealing and drawing operations.

There are two changes in specifications the authors strongly favor: the inclusion in specifications of a mercurous nitrate immersion test, and decreasing the minimum tin content from 1 per cent to 0.9 per cent. They believe these to be valuable changes and added safeguards to the purchaser, and they do not believe the other changes that have been proposed will result in insuring the purchaser that he will get a better tube or one which will last any longer in service. There are undoubtedly things which future experimentation may bring out to improve the quality and service of condenser tubes. When any such improvements are discovered, the authors' policy dictates that they promptly urge their adoption. (*Raw Material*, vol. 6, no. 3, Mar., 1923, pp. 97–103, illustrated, *gd*)

FOUNDRY

Casting Hubs Entirely in Cores, H. E. Diller. Description of a process in which the core has entirely displaced the mold in the sense that the entire mold is formed of cores without even the use of a flask.

The process refers to casting iron hubs on steel wheels. Because of the lack of space it is impossible to describe in complete detail the whole process. One feature is the use in the mold of an extra cover acting as a pouring core. This pouring core also has holes for the downgate and blow-off, and a strainer is placed in the hole for the downgate. This strainer is used, however, only on hubs which have to be machined.

The cores are made of a mixture of approximately 50 per cent old sand and 50 per cent new sand, bonded with a mixture of pitch binder and a binder produced by the Robeson Process Company, of New York. The original article describes in detail the equipment used for making and baking the cores, and also the somewhat unusual methods in melting the metal and finishing the castings. (*The Foundry*, vol. 51, no. 5, Mar. 1, 1923, pp. 169–175, 12 figs., *dp*)

FUELS AND FIRING

Terminology in Coal Research, Marie C. Stopes and R. V. Wheeler. The authors have been responsible, either severally or jointly, for the introduction of a number of terms into the literature of coal. In the present article they give the definitions of these terms.

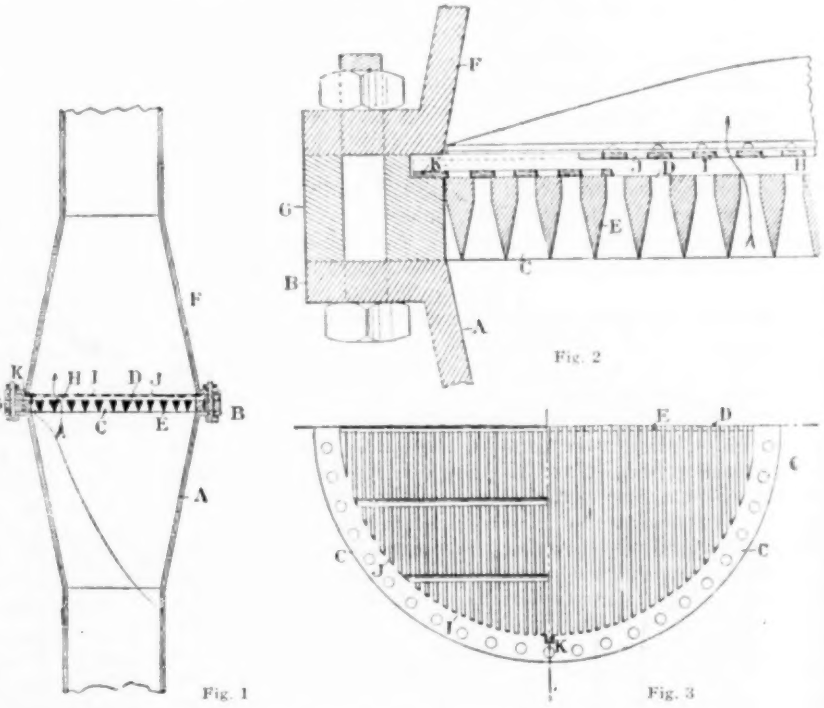
Of particular interest are the definitions and discussion of fusain, durain, clarain, and vitrain, these being illustrated by photomicrographs in black and in color.

The article is not suitable for abstracting as it deals chiefly with British coals, but the definitions of the constituents, of course, apply to American coals as well. (*Fuel in Science and Practice*, vol. 2, no. 1, Jan.-Feb., 1923, pp. 5–9, and 1 colored plate, *g*)

HYDRAULICS

Elimination of Water Hammer in Delivery Pipes

Device for Eliminating Water Hammer and Excessive Pressure in Delivery Piping, E. Maynard. The device described (Fig. 1) consists of a cone A placed over the delivery pipe. This cone is divergent, of variable length, and of a diameter suitably selected with respect to that of the pipe. It carries a small collar B supporting a steel plate C, perforated by parallel slots D, these slots being separated by bars E of triangular section in order that the water flowing may easily subdivide in order to pass over the grate thus formed. The total section of the slots must evidently be at least a little greater than the section of the pipe in order to reduce the loss of head due to the presence of the grate. Over the divergent cone A is placed a convergent cone F connected with the



Figs. 1, 2 and 3 Maynard-Tailleur Device for Eliminating Water Hammer in Delivery Pipes

delivery pipe. There is, however, a free space, say, 15 mm. (0.6 in.), between the upper part of the grate C and the bottom ring of the divergent cone. In this space H is placed a movable steel plate I provided with perforated parallel slots J, which do not, however, correspond to the slots in the grate above referred to. This plate can rise from 10 to 12 mm. (0.39 to 0.405 in.), but only under the effect of the pressure of the water produced in the delivery. This movable plate I is guided by four posts moving in vertical slots.

Figs. 1 to 3 show this system of grate valves. It is easy to understand how it operates. While the water is being delivered a movable plate which covers the slots in the grate is raised and remains raised in order to provide a passage for the water. When, however, the pumps begin to move slower or stop altogether the velocity of ascension of the water rapidly diminishes, and the plate, the inertia of which is small but which has a certain weight nevertheless, begins to move downward in the liquid and falls to the grate, the slots of which it closes the instant the velocity is reduced to zero, this action being rapid because of the short distance that the descending plate has to travel. As it is possible to regulate

the weight of this plate in a suitable manner so that it will fall to the grate at the precise instant when the velocity of the water is reduced to zero or changes in direction, it becomes possible to obtain a complete elimination of water hammer.

This result is of particular importance as it will make it possible to obtain marked economies in the construction of steel delivery pipe, for it will no longer be necessary to provide excessive strength to take care of water hammer.

The original article contains a numerical description of an application of this method which is patented in France. (*Revue Générale de L'Electricité*, vol. 7, no. 6, Feb. 10, 1923, pp. 211–213, 4 figs., *d*)

Complete Theory of the Centrifugal Pump, L. Bergeron. An extensive article not suitable for abstracting. The author is an instructor in applied hydraulics at the Central School of Arts and Manufactures in Paris and is considered to be one of the best experts on centrifugal pumps in France. (*France-Belgique*, vol. 1, no. 1, Jan., 1923, pp. 16–36, 12 figs., *g*)

INDUSTRIAL MANAGEMENT

Factory Organization. A collection of papers presented at the meetings of four organizations, one of which is The American Society of Mechanical Engineers (meetings of the other three societies being held in Germany).

The conclusion at which the editor, in commenting on these meetings, arrives is that America and Germany are the two countries where most of the work is being done for laying the foundation for the solution of the entire problem of organization.

It is significant that the majority of German papers are devoted not so much to scientific management proper, as it is understood in America, as to the organization of factory and cost accounting. The American Society of Mechanical Engineers papers are presented in detail. (*Werkstatts-Technik*, vol. 17, no. 5, Mar. 1, 1923, pp. 129–159, *g*)

INTERNAL COMBUSTION ENGINEERING

18-Hp. Cherub Aero Engines. Description of a two-cylinder engine developed by the Bristol Aeroplane Company, in particular for use on small aircraft of the glider type.

The engine is a flat twin air-cooled unit with cylinders of an aluminum alloy, with detachable head. The valve mechanism is of interest. A single camshaft with four integral cams, and driven by gearing from the crankshaft, lies inside the crankcase. The cams operate fingers, which, in turn, operate rocking shafts. The rocking shafts are returned by coiled springs and the mechanism is such that when the cylinders warm up there is no increased clearance between the rocking shafts and valves. Twin concentric springs are used for the valves and the whole mechanism is enclosed and automatically lubricated.

Two types of engines have been designed—one with the driving boss running at crankshaft speed to be used in conjunction with the chain-driven propeller, and the other with a two-to-one reduction gear enclosed in the crankcase. The engine has a bore of 85 mm. and stroke 94 mm., develops 18 hp. at 25 r.p.m., and weighs complete 85 lb. (*The Engineer*, vol. 135, no. 3506, Mar. 9, 1923, p. 270, 1 fig., *d*)

New British Lifeboat Motor, W. O. Horsnaill. Description of the motors recently installed in the lifeboats of the Royal National Lifeboat Institution and claimed to be the most reliable gasoline machinery in existence.

The motors are rated at 90 b.hp. at 800 r.p.m. and have six cylinders with a bore of $5^1/_2$ in. and a stroke of 7 in. Not only are they entirely enclosed but all the ports are watertight up to the level of the carburetor inlets, of which there are two and which are carried upward nearly to the top of the engine. To make assurance doubly sure the engine is installed in a watertight case with the control and instrument connections brought through watertight fittings. One of the features of the engine is the combination in one casting of a common tank-type water jacket with a complete crankcase, the latter entirely enclosing the crankshaft.

The two features which deserve particular attention are lubrication and water circulation. As regards the former, it should be borne in mind that automatic and effective lubrication of every moving part is a vital necessity in a lifeboat motor. It is impossible to open the case on a rescue trip and give an extra dose of oil to any part which has run dry. In this case a combination of pressure feed and splash lubrication has been adopted. (The details are given in the original article.)

As regards water circulation, the water circulates in a closed circuit which includes multi-tubular coolers in wells open to the sea, alternative sea connections being provided. The pump draws from either the coolers or the sea, delivering to the center of the tank jacket near the bottom. Thence the water rises through holes to the head and eventually reaches the jacket of an exhaust box which covers the two manifolds. An interesting feature is the grading of the holes to the head to give an equal quantity of water to all parts, according to their distance from the point of supply. From the exhaust box the water may go either overboard or back to the pump suction, the direction being regulated by a thermostat.

The reverse gear is of the epicyclic type with a multiple-plate clutch for the ahead drive. Much trouble has been experienced with reverse gears in lifeboats, hence meticulous care has been taken to guard any possibility of failure. Every part subject to torque is splined to its spindle—this feature including even the control gear—and every internal nut grooved and split-pinned, while outside screws have lock nuts or spring washers. An unusual feature is a locomotive-type shoe brake to hold the pinion gear box for going astern. The control shaft is fitted with a heart-shaped cam which nearly closes the carburetor throttles in the neutral and opens them out for going ahead or astern. A ball thrust block is fitted at the after end of the reverse-gear case, beyond which is a coupling, splined to the shaft and surrounded by a stuffing box to secure watertightness at this point.

A capstan on the fore deck is worked by a clutch in the flywheel. This clutch is fitted with a pinion which meshes with another on a horizontal shaft, the forward end of which drives the capstan through worm gear. By means of band control gear the clutch is forced into a cone in the flywheel with greater or less pressure according to the pull on the capstan. It will be easily understood that the 90 hp. of the engine would easily break any ropes being hauled or even the capstan gear unless some slipping device was provided. (*Pacific Marine Review*, vol. 20, no. 3, March, 1923, pp. 126–128, 5 figs., *d*)

MACHINE SHOP

Hobbing Tangent-Rack Gears. The Hotchkiss crown-wheel gear was described in Mechanical Engineering, vol. 44, June, 1922, p. 387. The present article illustrates the system used to generate this gearing by means of a conical hob which was devised by H. E. Taylor, chief engineer of the firm. The article describes both the principles of generation of this gear and the machine used. (*Engineering*, vol. 115, no. 2978, Jan. 26, 1923, p. 106, 7 figs., *d*)

MARINE ENGINEERING (See Internal-Combustion Engineering)

METALLURGY

New Method for Case-Hardening. Description of a process developed by Dr. Assar Gronwall, a Swedish scientist, inventor of the Electrometall type of electric shaft ore-smelting furnace. The process is based upon experiments which proved that as the gases enclosed in the case-hardening pots become saturated with carbonic acid, which happens fairly rapidly, the process gradually stops.

The new method consists of converting the carbonic acid as formed to carbon monoxide. This is done by putting catalyzers of a special metal in the form of thin sheets, ribbon, or wires, into the casing box with the carbonaceous matter surrounding material to be case-hardened. The catalyzer then acts in such a way that the carbonic acid, when coming in contact with the metal, passes into carbon monoxide. An iron object may be case-hardened deeper on a certain spot by placing catalyzer there. In the case of gear wheels, they were case-hardened only on the outer parts of the cogs.

The catalyzer is not consumed during the operation and therefore the expense for the new method consists only of the outlay for the original catalyzers and the license to operate.

With this method it is claimed that less carbonizing material is needed, that the temperature can be kept lower than in the usual method, and that the time required is about half that formerly necessary. The tests at the Technical Academy, Stockholm, consisted in treating pieces of steel from the same bar in an electrically heated furnace, first by the usual case-hardening method and second, with the addition of a catalyzer. The amount of case was considerably deeper in the second set of samples, although time occupied, temperature, and other conditions were exactly the same. (*Iron Trade Review*, vol. 72, no. 9, Mar. 1, 1923, p. 660, *d*)

PHYSICS

Glue Bubbles, Carl Barus. The work of Dewar (Journal A.S.M.E., April, 1918, p. 349) and others on soap bubbles have shown that important information can be derived from the behavior of these bodies. The present article deals with glue bubbles, and, in particular, the measurement of pressure increments within the bubble, which the author claims can be done by an interferometer which he has designed.

Glue bubbles can be obtained directly and are sometimes obtained so that they actually last indefinitely; these solid glue bubbles may be ultimately detached. The author discusses the growth of the bubble and shows graphically the result of the successful dilution of the original liquid glue. It would appear that the surface tensions remains low and nearly constant until a dilution of the order of 0.005 is reached, and therefore with further dilution the surface tension increases very rapidly. (*Science*, vol. 57, no. 1466, Feb. 2, 1923, pp. 151–153, 1 fig., *e*)

POWER-PLANT ENGINEERING (See also Engineering Materials)

Some Deductions from Indicator Diagrams, Alberto Keens. Extensive discussion of a practical nature of the indicator diagram and what it teaches. The author has made no special attempt to present anything except a, clear practical discussion of his subject, containing such information as would be of use, for example, to a sea-going engineer or an engineer in charge of steam engines; special attention being paid to the salient factors upon which the smooth and economical running of the engine depends.

The paper is not suitable for abstracting but would prove to be of considerable interest to students in engineering and all those who wish to clarify their practical knowledge of the indicator diagram. (*Institute of Marine Engineers*, paper read Jan. 30, 1923, abstracted through advance copy, illustrated by numerous diagrams, *p*)

POWER TRANSMISSION

Mechanical and Electromechanical Oscillations, Henrich Schieferstein. On page 254 of Mechanical Engineering, April, 1923, there appears an abstract describing the general principles of the Schieferstein method of power transmission by oscillations. The present article describes the same subject in greater details and illustrates by drawings and photographs some of the machinery employed. Among other things it mentioned the use of oscillating planes for aircraft. (Abstract of paper read before the Verein deutscher Naturforscher in Leipzig, Sept. 19, 1922, abstracted through *Zeitschrift f. Technische Physik.*, vol. 3, no. 12, 1922, pp. 377–380, 11 figs., *d*)

PUMPS

High-Speed Pump with Ring Valves. This pump, built by the Pulsometer Engineering Company, Reading, England, is of the reciprocating single-acting plunger type fitted with rubber ring valves working on gun-metal seats. The pumps of this type are built in sizes to deliver from 250 to 2000 imperial gallons per hour at heads up to 100 ft. They are designed to run at speeds from 300 to 500 r.p.m., which makes them suitable for belt driving from high-speed electric motors. The pump casing is cast in one piece with the enclosed crank chamber. The front part of the gun-metal plunger acts as a crosshead working on a guide extending into the crank chamber, and thus relieves the plunger and stuffing box from all side strain. The connecting rod is of gun metal with a marine-type large end which works on the pin of a balanced crank.

The suction valves are in the internal grooves and work in compression, while the delivery valves are in the external grooves and work in tension. The aggregate area of the water passages is large, so that the only movement of the valves consists in a very slight compression or elongation of the rubber. The pumps can therefore work at very high speeds with absolute silence under all conditions. (*Engineering*, vol. 115, no. 2981, Feb. 16, 1923, pp. 217, 6 figs., *d*)

Gyroscopic Pumps

Gyroscopic Pumps, Morris Gendrin. In view of the fact that little information is available in English as to these pumps, a somewhat extended abstract of the article is deemed advisable.

In the first place, certain mechanical principles have to be recalled. All movements of an aggregate of material points may be referred to a system of axes arbitrarily movable in space. We have the right to do this, provided we assume that at each of the material

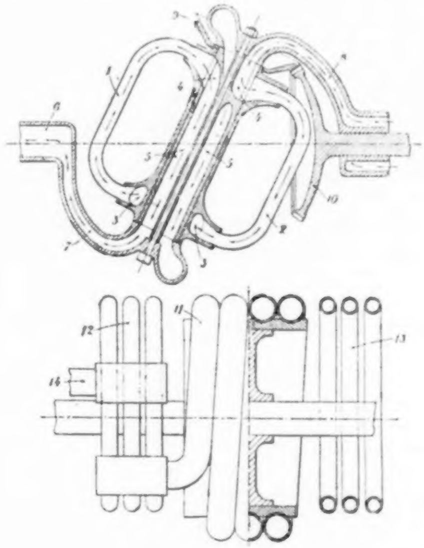
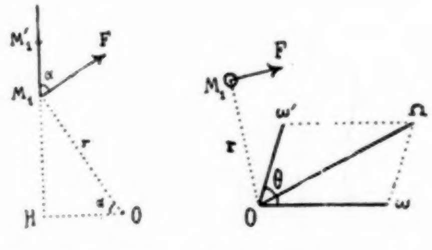


Fig. 4 Diagrammatic Views of Two Types of Gyroscopic Pumps



Figs. 5 and 6 Diagrams of Forces Acting in a Gyroscopic Pump

points M two apparent forces are applied, namely, the inertia of entrainment and the component centrifugal force.

The force of inertia of entrainment is the product of the mass times acceleration of entrainment with the sign changed, the acceleration of entrainment itself being the acceleration of a point referred to movable axes which coincide with the point M at the instant under consideration.

The component centrifugal force is the product of the mass by the complementary acceleration with the sign reversed. If, beginning with the instantaneous axes of the rotation of entrainment, the vector OV be equal to the relative velocity of the point M, the complementary acceleration is equal to twice the velocity which the point V would have under the action of the instantaneous rotation of entrainment. A rotation is often represented by a vector OA projected on the axis and equal to the angular velocity. If the axis

is fixed and the movement uniform, the force of inertia is merely a centrifugal force as generally known.

Assume now, however, that either the direction or the magnitude of the vector OA varies, the point O remaining fixed, which means that A has a certain velocity AB; also take $O\beta'$ equal to AB. It can then be shown that the acceleration is equal to the magnitude which it would have if OA were fixed, plus a component equal to the velocity which would be impressed on the point M by a rotation $O\beta'$. Whereas the centrifugal force tends to draw away from the axis all the material points, the second component tends to make them rotate all in one direction and it is this force that is used in gyroscopic pumps by their inventor, Emil Faure.

Principle of Gyroscopic Pumps. A movable part consists of an aggregate of passages, and for purposes of discussion it is convenient to consider the axes referred to these passages. Under these conditions there occur a certain number of forces producing a displacement of the fluid. These forces may be considered here in succession: first, external forces, in this case gravity; next, the difference of pressures between two adjoining sections of the same passage; third, the action of walls perpendicular to the velocity (owing to a proper selection of the axes) which, however, does not affect the movement of the fluid in the passage. The same definition applies to the component centrifugal force. Next comes the ordinary centrifugal force as used in centrifugal pumps; this is produced by a potential. In gyroscopic pumps, however, there are only two groups of forces that come into action, namely, the pressures and the components due to variations of the velocity of rotation. In other words, an effort is made to obtain a difference of pressure by constantly varying the instantaneous velocity of rotation. Two extreme types have been considered by Faure: in one the direction of rotation alone varies; in the other the magnitude of rotation alone varies (for example, oscillating rotation).

First Type—Description. A certain number of passages 1 and 2 (Fig. 4) mounted two by two in series inside of the curved body 3, constitute the inlet to the pump. Their free ends communicate with the cylindrical valve 4 forming part of the central tube 5. The motor drives the hollow shaft 6 and this governs the rotation of the conduits 7, 5, and 8 which are connected to the valve. The gear connected to the inductor meshes with gear 10 which is stationary, and thereby gives the inductor a second movement about the relative axis formed by the central tube 5.

The cylindrical valve 4 is so arranged as always to give to the fluid circuit the shape shown by the figure. At the same time the bisector planes of the two orifices of the valve form a certain angle with the plane of the axes of rotation, the purpose of this being to reduce for a certain output the losses of kinetic energy due to impact of the fluid against the walls of the valve. (This arrangement is somewhat similar in principle to the shifting of the brushes of electrical machines.) The pressure may be adjusted to any value below the maximum, and this without changing the velocity, by regulating the position of the valve by rotating it about its axis.

Operation. Assume that an observer standing on the right-hand side sees the shaft 6 rotating in the direction of the hands of a clock. An observer standing above the machine will see the indicator turn in the same direction. The two rotations, of entrainment and relative, are represented by the vectors ω and ω' and they combine into an instantaneous rotation Ω. The extreme end of the vector Ω driven by the rotation ω has a velocity $\omega\omega'\sin\theta$ perpendicular to the plane of the figure and away from the observer. In accordance with the theoretical considerations set forth above, a material point M projecting into M_1 is acted on by a force $F = m\omega\omega' r \sin\theta = Kr$ (Fig. 6). This explains why the liquid in Fig. 4 follows the path indicated by the arrows. With this in mind it is very easy to carry out the calculations. Here merely the result will be given. The work which a force F exerts in producing a displacement $M_1M'_1$ of a point M_1 is equal to—

$$M_1M'_1 + Kr\cos\alpha = K \times M_1M'_1 \times OH = 2K \times \text{area } OM_1M'_1 \quad (a)$$

As a result the work applied to a mass m of a liquid is equal to $W = 2m\omega\omega' \sin\theta S$, where S is the projection of area of the circuit on the plane of the figure. If V is the volume of this liquid mass having a density ρ, then $W = V(p - p_0)$, and consequently $p - p_0 = 2\delta\omega\omega'\sin\theta S$. If the liquid flows through a circuit the sectional area of which is 1 sq. dm. and the two shafts (perpendicular) make 10 r.p.s., the pressure will be 0.8 kg. or 8 m. of water, which shows that it is possible to obtain considerable pressures without making the velocity excessively high.

The second type of pump, shown in the lower half of Fig. 4, namely, one where the velocity of rotation alone varies, is also described in the original article, but cannot be discussed here owing to lack of space. (*France-Belgique,* vol. 1, no. 1, Jan., 1923, pp. 69–71, 3 figs., *dA*)

RAILROAD ENGINEERING

Willamette Geared Locomotives. Brief description of geared locomotives manufactured for logging purposes by the Willamette Iron and Steel Works, Portland, Ore. The locomotive uses a side drive and is equipped with a three-cylinder vertical engine

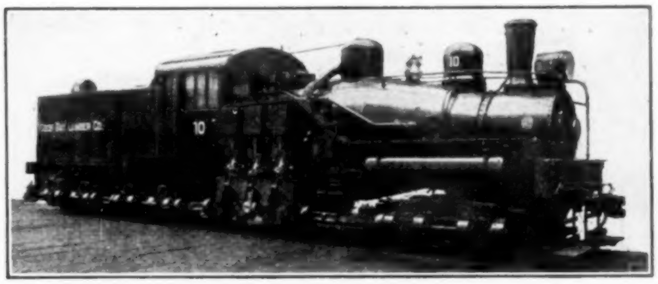


Fig. 7 Geared Locomotive Built by the Willamette Iron and Steel Works, Portland, Ore.

capable of developing approximately 900 hp. The boiler carries a working pressure of 200 lb. and is built in accordance with the requirements of the A.S.M.E. Code. The Walschaerts type of valve gear has been adapted. A photograph of the locomotive is reproduced in Fig. 7. (*Railway Age,* vol. 74, no. 16, Mar. 24, 1923, pp. 809, 1 fig., *d*)

New Cars of Special Design for the London Electric Railway. The London Electric Railway Company (Associated Underground Companies) not long ago gave an order for one car each to five leading rolling-stock construction firms, giving them practically permission to build cars to their own designs, in addition to which one car built to the design of the Underground engineering staff was also placed in service.

Among the features introduced may be mentioned the position and width of the doors, which is uniform in all the cars, namely, a pair of double doors spaced along each side of the car. A further feature is the attempt which has been made to provide as silent running a car as possible. Dr. Low, on behalf of the company, has taken photographs of the sound heard in an ordinary underground subway car when in motion and it was found possible to locate the principal causes of noise. Steps were taken to reduce this and the experience thus gained has been utilized in designing the sample cars. The original article gives an internal view of the cars which are extremely unlike anything used in America. The cars are described as being "de luxe."

The ventilation in the cars is so designed that there will be no need to have windows open while traveling. The original article describes the five cars in detail. (*The Railway Gazette,* vol. 38, no. 6, Feb. 9, 1923, pp. 195–199 and 202, 8 figs., *dA*)

Mikado Locomotives vs. Electrification on the D. L. & W. About 40 per cent of the traffic on the Delaware, Lackawanna & Western consists of anthracite coal mined in the vicinity of Scranton. Scranton and the coal mines are located in a valley with heavy grades—about $1^1/_2$ per cent—in both directions, the grade toward the east being considerably longer than the west-bound grade.

In order to equalize the operating capacity of the road plans were drawn for the electrification of some 40 miles of gradients near Scranton, the intention being to furnish electric-locomotive helper and pusher service to the summits for the east- and west-bound traffic. It was found, however, that the cost of the project would be in excess of \$5,000,000, as a result of which the company decided to postpone electrification for the time being and to purchase in-

stead 40 powerful Mikado-type locomotives. This was done and coal trains are now made up and taken through solid from Scranton to the west or to the seaboard. The new Mikado locomotives with the helper service are hauling trains of 2900 tons through from Scranton to the Secaucus yards, near Hoboken.

With these powerful locomotives a larger tender is used, the capacity having been increased from 10,000 gal. of water and 12 tons of coal to 12,000 gal. of water and 14 tons of coal. This increased capacity enables the locomotives under ordinary conditions to take a train to the summit east of Scranton without taking water and to run 130 miles from Scranton to Secaucus yard without taking coal.

The 40 new locomotives are noticeably heavier than those already in service, and in terms of tractive force are the most powerful Mikado locomotives ever constructed. They were designed by the American Locomotive Company to meet the special traffic conditions on the D. L. & W. and were built at the Schenectady works.

The new Mikado locomotives have 10,600 lb. greater tractive effort than those previously used by the same road. An increase in tractive force of the main cylinders was obtained by changing the piston travel from 30 in. to 32 in. and raising the steam pressure from 180 lb. to 200 lb. The weight of the locomotive was also increased with the result that there is now an axle load of 68,000 lb., which would not have been permissible except for the favorable track and bridge conditions prevailing on the Lackawanna. A booster is also installed, in addition to which are used an Elvin mechanical stoker and a Baker valve gear, together with other modern special equipment.

These D. L. & W. Mikado locomotives will naturally be compared with those for the New York Central Lines, one of the most striking designs brought out in 1922 and for which orders were placed for 191 for the various roads comprising that system. The New York Central locomotives weigh 334,000 lb. in working order, have 28-in. by 30-in. cylinders and 63-in. driving wheels. They also are equipped with boosters and have a total rated tractive force of 74,500 lb., or 63,500 lb. without the booster. Other heavy Mikado-type locomotives recently ordered are those for the Central of New Jersey weighing 342,500 lb., having 27-in. by 32-in. cylinders and a rated tractive force of 59,000 lb., and those for the Northern Pacific weighing 337,000 lb., having 28-in. by 30-in. cylinders and a rated tractive force of 57,000 lb. But few Mikado locomotives having a tractive force of over 60,000 lb. have been built. (*Railway Age*, vol. 74, no. 9, March 3, 1923, pp. 511–513, 5 figs., *dc*)

REFRIGERATION

An Oscillating Ammonia Compressor

Oscillating Ammonia Compressor, H. J. Macintire. A description of what is claimed to be a new type of compressor. The action of the machine is as follows: Referring to Fig. 8, the suction gas enters through pipe *A* into the hollow rotor shaft *B*, which has a long slot *D* through which the gas may pass into the compressor cylinders *C* when the rotor has rotated far enough for that purpose. It will be noticed that the rotor makes with the cylinder *E* four compression chambers *C*, which are single-acting. The gas enters when the ports are uncovered and is discharged through disk-type discharge valves into the annular space *F*, from which it passes to the oil-filled chamber *G*. The compressed ammonia with entrained oil then passes into the dome *H*. From *H* it is led through a pipe connection to the filter chamber *J*, which is filled with material suitable for the collection of mist particles and the formation of drops. The oil then falls in drops into the oil reservoir *K*, while the ammonia gas is taken through the standpipe *L* into the two shell and coil condensers *M*. The oil from the reservoir *K* is then returned to the compression chamber. It is first led by means of a pipe *M* into the end of the cylinder casing, from which, by means of an oil-measuring device *Q*, it is given passage into the suction gas at *B*.

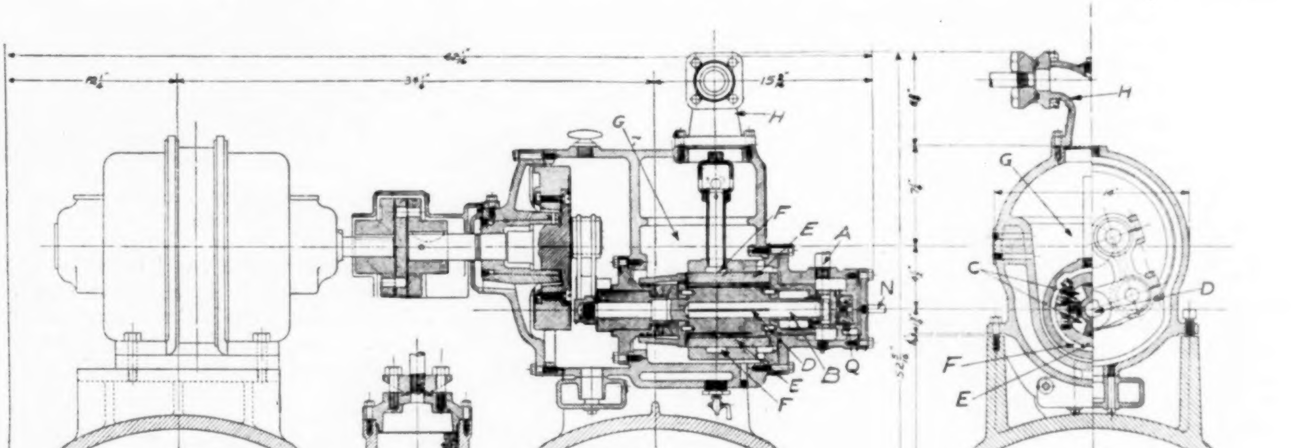


Fig. 8 Oscillating Ammonia Compressor

The rotor is driven by means of a four-bar linkage mechanism, and is designed to rotate through a 69-deg. arc at a speed of 850 oscillations per minute. The compressor is operated practically flooded in oil, reliance being placed on the efficiency of the filter to remove all traces of oil from the ammonia. The ordinary stuffing box is replaced by a self-aligning metal seal *R*. Any oil leaking by this seal will collect in the sump *S*, from which it can be drained occasionally. The shell and coil condensers, in the smaller design, make a convenient frame on which to support the motor and compressor.

It is claimed that the field for such a compressor is in the smaller

designs, especially in view of the noiseless operation of the compressor.

In the discussion which followed, the author in reply to a question stated that he had had but three or four weeks of experience with the device under conditions where gas must leave the cylinder highly impregnated with oil, but the liquid ammonia showed up in the gage glass perfectly clear. (*Refrigerating Engineering*, vol. 9, no. 8, Feb. 1923, pp. 252–253, 2 figs., *d*)

SPECIFIC VOLUME OF SATURATED AMMONIA VAPOR, C. S. Cragoe, E. C. McKelvy, and G. F. O'Connor. Data of extensive experiments carried out at the Bureau of Standards some years ago. The paper presents a discussion of previous measurements and data of the present investigation. Among other things, a form of empirical equation expressing specific volume as a function of temperature has been derived.

A form of empirical equation was sought which would represent the results closely and which would also satisfy the terminal conditions at the critical temperature. The equation should, at that temperature, give a finite value for the specific volume u' and approach the value $-\alpha$ for the derivative $\frac{du'}{d\theta}$. In view of the approximate reciprocal relationship between specific volume and vapor pressure, an equation similar to the vapor pressure-temperature equation suggested its possible usefulness with an additional term which would make it satisfy the second condition mentioned above. As in the case with vapor pressure, no simple relation has been found which can be used even over a comparatively small interval of temperature.

An equation of the form—

$$\log u' = A + \frac{B}{\theta} + C \log \theta + D - \sqrt{\theta_c - \theta} + E(\theta_c - \theta)$$

where θ_c is the critical temperature, was found to meet the above requirements.

The measurements were carried out by two methods, one involving a direct determination of the mass of vapor contained in a known volume, and the other an optical method involving measurements of the index of refraction of the vapor, from which the density of the vapor could be determined. The values for the specific heat were calculated from the Clapeyron equation, using other data obtained at the Bureau. The experimental results found by the two methods are in fair agreement with the calculated values above 0 deg. cent., differing at most by about 0.3 per cent. Below 0 deg. cent. the results found by the direct method are systematically lower and those found by the optical method are systematically higher than the Clapeyron values, amounting to about 2 per cent at -50 deg. cent. The calculated values were chosen, therefore, as the most probable values. The possible sources of error in the two methods are discussed.

The final results are represented closely by the empirical equation:

$$\log_{10} u' = 300\left[\frac{6.46344}{\theta} - 0.106887 + 0.0356803 \log_{10}\theta\right]$$
$$+ 0.0862366\ \sqrt{406.1 - \theta}\ +\ 0.002667\ (406.1 - \theta)$$

in which u' is expressed in cubic centimeters per gram and θ in degrees absolute (deg. abs. = deg. cent. + 273.1). (*Refrigerating Engineering*, vol. 9, no. 8, Feb., 1923, pp. 239–248 and 258, bibliography, 4 figs., *e*)

SPECIAL PROCESSES

FORGING STEEL TUBING INSTEAD OF DRAWING IT, Chester Warner. Description of a process developed by the author in collaboration with E. Warner. It is claimed that by this process large square, round and other internal sections can be made in wall thicknesses of $^3/_4$ in. and up, and in lengths up to 8 ft.

In this process a block of steel of the required weight is pierced with a hole $^1/_4$ to $^1/_2$ in. larger than the size it is to be at the finish. It is carefully inspected and then reheated and placed under a high-speed hammer, where the roughing mandrel is inserted and the block roughed out to the length of the tool, after which the tool is withdrawn and the tube reheated. This last is done very slowly to insure uniform temperature throughout the entire tube. The tube is then again taken to the hammer, the finished mandrel inserted, and the tube drawn to size. Water is employed in this operation as a cooler. If the tube sticks it is only necessary to allow tube and tool to cool, after which the tube may be withdrawn with ease.

It is stated that in no operation has the waste exceeded 10 per cent, and that the ends have been found free from cracks when as little as $^3/_8$ in. has been cut off from them.

Difficulty was at first experienced with the steel used in the mandrels which must withstand severe use. They must not only retain hardness under high temperatures but also keep a smooth, clean surface—not crack or warp. These qualifications have not yet been fully attained, but progress has been made; the mandrels, however, will crack once in a while. The tubes have a slight taper, the dimensions of which for the various sizes are not given. (*Raw Material*, vol. 6, no. 3, Mar., 1923, pp. 90–91, 5 figs., *d*)

STEAM ENGINEERING (See Thermodynamics)

THERMODYNAMICS

INTERNAL-COMBUSTION HEAT LOSSES AND SPECIFIC HEAT OF WORKING FLUID. A somewhat general discussion from which only certain points can be abstracted on account of lack of space.

It is frequently stated that the gaseous medium of closed-vessel tests is highly transparent to its own radiation. The writer questions this assumption for two main reasons, the first being that the diathermancy of the gases will decrease with increasing density. This explains the apparently lower values of specific heat at the higher densities. The reason for the relatively high explosion pressures attained by Professor Petavel in his experiments thus lies in the diminished radiation losses at high densities. In the case of any gases consisting of particles of H_2O the interception of radiated heat by such particles must, at least, be appreciable. Indeed, the fact that the specific heats at constant pressure and constant volume may be written

$$\left(\frac{dK_p}{dP}\right)_T = -T\left(\frac{d^2V}{dT^2}\right)_p$$

and

$$\left(\frac{dK_v}{dV}\right)_T = T\left(\frac{d^2P}{dT^2}\right)_v$$

respectively, is a strong argument against any variation of specific heat with density at high temperatures, since the departure from the usual gas law at such temperatures can scarcely be to the extent required to make the argument valid.

The second reason for non-belief in the high transparency of the gases to their own radiated heat is based on the conviction that during the first half-second of the explosion at least, heat losses in closed-vessel tests are almost wholly radiation losses. This conviction is upheld principally by the fact that test results on explosion vessels of different dimensions can be thereby reconciled. For high transparency, total heat losses on this view, should, in explosion-vessel tests, be proportional to l^3. Actually they are not so proportional. Various figures put forward by different experimenters for the value of the index n in the relation

$$\text{Total heat losses} \propto l^n$$

all agree that n is less than 3. If heat losses in such closed-vessel tests are practically all radiation loss at the outset, as the writer contends, high transparency would give the l^3 law. The only possible argument will be proportional to l^2, and so, in effect, will reduce the index n to some value between 3 and 2.

The author proceeds to show from both experimental and analytical evidence that this reduction in the value of n may be explained by relatively low discrepancy of gases to radiated heat, while holding at the same time that the initial conduction loss (enclosed-vessel test) is practically negligible.

The author surveys some engine tests for purposes of comparison with explosion-vessel tests and derives the following values of the specific heats at constant pressure and constant volume:

$$K_p = 316 + 0.0623\ T \text{ ft-lb. per lb. per deg. cent.}$$
$$K_v = 220 + 0.0623\ T \text{ ft-lb. per lb. per deg. cent.}$$

He plots the internal-energy lines based on the specific-heat values and compares with them lines derived from various authorities, the results showing large discrepancies between these different values. He points out, however, that his values are practically coincident with the values of the specific heats of carbon dioxide, nitrogen and air as measured by Professor Dixon and others, by measurements of sound velocity in the medium. (*The Engineer*, vol. 115, no 3504, Feb. 23, 1923, pp. 191–192, 3 figs., *tA*)

Fundamental Properties of Water Vapor

Fundamental Properties of Water Vapor, Prof. M. Strauven. An analytical discussion, only part of which can be referred to here. Among other things, the author carries through a careful comparison of the systems of values of Callendar and of Eichelberg, and shows that the difference between the two sets of values may be as high as 1 per cent. It is, however, of greater importance to determine not so much the absolute values of I (total energy) as its variations between two given states (the fall of total heat). In practice, expansions beginning with the state of superheated steam end quite often in saturation, a region for which the expression for I takes the form—

$$I = q + xr + Apv.$$

From this the author proceeds to consider the three cases of adiabatic expansion and shows that the differences in results between the Callendar and Eichelberg equations may be, under certain conditions, as high as 6 per cent, which occurs mainly, however, when the initial and final expansion pressures differ but little from each other. This is due to the fact that the absolute values of I in the Callendar and Eichelberg equations are sensibly equal for the high and the low temperatures, but give different results for the region of intermediate temperatures.

The author considers next the specific heats of superheated steam and comes to the conclusion that the values of C_p (Callendar) at high pressures do not agree with the direct measurements of the Munich tests. On the other hand, however, the Munich tests agree perfectly for the region of low pressures with the values experimentally obtained by Callendar. Callendar defended his values by pointing out that the values of C_p at saturation were obtained in the Knoblauch tests by means of a purely empirical extrapolation of experimentally obtained isobars. This objection was answered, however, when Eichelberg succeeded in working out an equation of state of dry steam instead of the extrapolation formula of C_d obtained from this equation of state, and the Callendar equation may be put in the form of—

$$C_p = C_{p_0} + 0.334 \frac{p}{T^{13/3}}$$

The Thomson-Joule effect is discussed next and it is stated that the divergence between the experimental values of Callendar and the calculated values of Eichelberg is comparatively small, which is noteworthy since the determination of the Thomson-Joule effect by means of a throttling calorimeter is an extremely delicate operation, and, for example, the presence of 1 per cent of moisture in the steam at the entrance to the calorimeter may cause a variation of 10 deg. in the temperature of the steam at the exit. Because of this the agreement between the Callendar and Eichelberg values is all the more interesting.

The properties of dry saturated steam are discussed next. In this connection attention may be called to the discussion of the *I-S* diagram as proposed by Schuele, in particular the discussion as to the values of r from the Munich experiments and the Eichelberg equation. There is a material difference between the two, especially above 180 deg., the Schuele values being usually considerably higher. It is the opinion of the author that the only way to determine the cause of these differences is to carry out new experiments on the heat of vaporization of steam at high temperatures. At the same time he points out that the values adopted by Schuele for the high temperatures lead to the conclusion that in that region the total energy at constant temperature may, under certain conditions, increase with the pressure, but the specific volume of a vapor, the conditions of temperature and pressure being equivalent, is always inferior to that of a perfect gas having the same characteristic constant R, and from this the author deduces that with an increase in pressure and constant temperature the total energy gradually decreases, which is contrary to the conclusion resulting from Schuele's values but is in accordance with the relations of Eichelberg and is proved by the values obtained by Callendar. Since, further, the heat of vaporization r appears in the calculation of the entropy of steam, it would follow that Schuele's *I-S* diagram must give values for high pressures which are materially different from those obtained by Eichelberg, and this difference may be in excess of 2 per cent—and even more under certain conditions.

The conclusion at which the author arrives is that of giving preference to the values derived from the equation of state of Eichelberg. He points out at the same time, however, that this equation has been experimentally proved only for pressures up to 25 atmos. and should have further experimental confirmation before being used for extrapolation to higher pressures. From this point of view it would be desirable to study experimentally at high pressures and high temperatures the Thomson-Joule effect, the heat of vaporization, and the value of the exponent in the adiabatic equation. (*Revue Universelle des Mines*, vol. 16, nos. 4–5, Feb. 15 and Mar. 1, 1923, pp. 289–301 with 1 plate of diagrams, and pp. 363–376 with numerous tables and curves, *tA*)

VARIA

Polytopical Clocks with Time Spiral Showing World Time, R. Hirsch. Description of a world-time clock with rotating face and without hands exhibited in the German Museum at Munich. In this clock a map of the world is printed on the face and the clock is so arranged that once the desired city is found on the map the time in that place can be read off, though, it must be stated, not with ease.

Another type of clock for a similar purpose has hands and a stationary 24-hr. face. The hands are fastened on a map of the world in the places representing the locations of the different towns. The map is, however, of a somewhat unusual type, in that while the meridians appear as usual the latitudinal lines have retained their circular shape, but attain their largest diameter at the south pole instead of at the equator. This clock must turn from right to left corresponding to the rotation of the earth from west to east. It also deviates from the ordinary clocks inasmuch as it must be fitted with a special movement, permitting of one rotation of the hour hands within 24 hr.

A method is also described for converting any ordinary 12-hr. watch or clock into a world-time clock without alteration of the movements or works. To achieve this purpose, besides the normal hour hand for the local time several additional hour hands are provided which are fixed at the proper angular distance from the main hour hand and which turn together with the latter. (*Engineering Progress*, vol. 4, no. 3, Mar., 1923, pp. 51–52, 3 figs., *d*)

Doctor of Engineering "Honoris Causa." The German Association of Technical and Economic Societies has issued a protest against the liberal grants of the degree of honorary doctor of engineering by German technical schools where the reason for granting the degree is not the scientific or technical achievement of the recipient but his willingness to make to the institution of learning contributions in coin of the realm. (In particular is mentioned the case of a member of a Berlin firm manufacturing confectionary who has been granted an honorary degree of doctor of engineering by the Technical High School at Carlsruhe, although apparently his name was entirely unknown in connection with any technical or scientific achievements.) It is claimed that such policy on the part of high German institutions of learning will bring disrespect on them and deprive the honorary degrees of any true value. (*Giesserei Zeitung*, vol. 20, no. 2, Jan. 9, 1923, p. 18, *g*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general, *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Viscosity of Lubricating Oils at High Pressures

Progress Report of Special Research Committee on Lubrication

THE A.S.M.E. Special Research Committee on Lubrication was organized in 1915 to investigate the fundamental problems of lubrication phenomena, and has issued progress reports in 1919 and 1921. These may be consulted for information as to the scope of the work in hand and previous results obtained.[1]

The present report contains a further account of the experimental work at high pressures, which has been continued during the past year by M. D. Hersey at the Massachusetts Institute of Technology. This report covers the measurement of the viscosity of several different lubricating oils at temperatures up to 100 deg. cent. and pressures up to about 50,000 lb. per sq. in.

Essentially the same apparatus previously referred to has been employed, the viscosimeter being of the rolling-ball type due to A. E. Flowers, while the pressure measurements were based on the change of electrical resistance of a suitable manganin coil. This method of pressure measurement was originated by Prof. P. W. Bridgman and has since been satisfactorily used elsewhere. A new pump, specially designed for this work through the kindness of Professor Bridgman, was installed at the beginning of the year.

All the above details naturally require a more voluminous report than can be prepared at this date, as the work is still in progress[2] and improvements are constantly being made. The present report, therefore, is only intended to show the general character of the results which are being secured.

Three fixed oils—lard, sperm, and castor—and three mineral oils—Veedol, Texaco, and Mobiloil A—have thus far been tested. Table 1 gives the approximate relative viscosity of these oils at intervals of 500 kg. per sq. cm. and at different temperatures.[3]

TABLE 1 APPROXIMATE RELATIVE VISCOSITY OF VARIOUS LUBRICATING OILS

	Lard		Sperm		Castor		Veedol (med.)		Texaco (med.)		Mobiloil A		
Pressure, kg. per sq. cm.	22 deg. cent.	100 deg. cent.	22 deg. cent.	100 deg. cent.	22 deg. cent.	100 deg. cent.	22 deg. cent.	100 deg. cent.	24 deg. cent.	100 deg. cent.	24 deg. cent.	40 deg. cent.	100 deg. cent.
0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
500	2.4	1.5	1.9	1.4	1.9	1.3	3.2	1.7	4.0	1.3	5.3	7.8	1.3
1000	4.2	1.9	...	...	3.6	2.2	11.7	3.3	14.7	1.7	28.6	21.2	3.4
1500	9.7	2.3	...	...	...	3.5	...	6.1	...	3.0	...	322.0	8.2
2000	...	3.0	...	...	...	5.2	...	9.9	...	5.3	...	...	64.0
2500	...	4.2	...	...	...	9.0	...	15.5	...	9.0	...	...	...
3000	...	6.1	...	...	...	...	...	25.4	...	16.0	...	...	...
3500	...	...	...	...	...	...	...	...	...	21.2	...	...	...

Approximate values only are available, as several small corrections remain to be computed, particularly those due to the compressibility of the oils, but it is not thought that the figures quoted are subject to changes greater than 5 per cent.

By "relative viscosity" is meant the ratio of the absolute viscosity at a stated pressure and temperature to the absolute viscosity at atmospheric pressure and that same temperature, e.g., 100 deg. cent.

Thus, the data for lard oil show that at 1000 kg. per sq. cm. (14,200 lb. per sq. in.) and 22 deg. cent. its viscosity is four times as great as at atmospheric pressure and 22 deg. cent.; whereas, by contrast, Texaco at 1000 kg. per sq. cm. and 24 deg. cent. has 14.7 times as much viscosity as it had at atmospheric pressure and 24 deg. cent. and therefore shows a more pronounced pressure effect than lard oil. Again, lard oil maintained at 100 deg. cent. experiences a 1.9 fold increase of viscosity under 1000 kg. per sq. cm., while the corresponding effect for Texaco is only to increase its viscosity 1.7 times.

It is to be noted that our present use of the term "relative viscosity at 100 deg. cent. and 1000 kg. per sq. cm. pressure" means that the viscosity under high pressure is being expressed in terms of the viscosity at atmospheric pressure and 100 deg. cent., *not* in terms of the viscosity at atmospheric pressure and 22 deg. or 24 deg. cent. This seems to be a fair way to compare different lubricants in respect to the influence of pressure upon them, though other methods of correlation are being considered.

Table 2 supplements Table 1 by giving the approximate absolute viscosities of the several oils at different temperatures under atmospheric pressure. Table 1, for example, does not show how much more viscous Texaco at 100 deg. cent. and 1000 kg. per sq. cm. may be than lard at 100 deg. cent. and 1000 kg. per sq. cm. By reference to Table 2, however, it can be deduced that under those conditions Texaco is only 0.7 as viscous as lard, while in like manner it is found that lard oil at 100 deg. cent. and 1000 kg. per sq. cm. is 0.4 as viscous as at 22 deg. cent. and atmospheric pressure.

At moderate temperature all of the oils were found to become exceedingly viscous, or else suddenly plastic, at some fairly definite pressure and hence, practically speaking, to have solidified. These solidifying pressures are recorded in Table 3.

The original observations on which this report is based are about 250 in number, exclusive of check observations, and will later be prepared for publication in the form of curves, showing absolute viscosity as a function of pressure and temperature. The viscosimeter has been calibrated for this purpose with due allowance for variations in the density of the oil, as explained in previous papers.[1]

TABLE 2 ABSOLUTE VISCOSITY OF VARIOUS LUBRICATING OILS AT DIFFERENT TEMPERATURES UNDER ATMOSPHERIC PRESSURE

	Viscosity c.g.s. 22 deg. cent.	Viscosity c.g.s. 100 deg. cent.
Lard	0.67	0.15
Sperm	0.39	..
Castor	7.8	0.23
Veedol	0.97	0.09
Texaco	1.1[1]	0.12
Mobiloil A	2.0[1]	0.10

[1] Viscosity at 24 deg. cent.

TABLE 3 APPARENT SOLIDIFYING PRESSURES OF VARIOUS LUBRICATING OILS

	Temp., deg. cent.	Pressure kg. per sq. cm.	Pressure lb. per sq. in.
Lard	22	1600	22,800
Castor	22	1400	19,900
	100	2900	41,200
Veedol	22	1300	18,500
Texaco	24	1500	21,300
	100	3900	55,500
Mobiloil A	24	1200	17,100
	40	1500+	21,300+
	100	2100	29,800

Acknowledgments for individual assistance are due primarily to H. B. Henrickson of the Bureau of Standards in connection with the earlier development work, and more recently to C. W. Staples, a graduate student at Massachusetts Institute of Technology during 1922 (W. P. I. '19), and Henry Shore, M.I.T., '24. Mr. Staples was largely responsible for the pump development and other mechanical problems, while Mr. Shore gave particular attention to the temperature control and other electrical problems introducing various improvements which will be described later.

ALBERT KINGSBURY, *Chairman*
MAYO D. HERSEY
A. WILMER DUFF
H. C. DICKINSON
A. E. FLOWERS.
Research Committee on Lubrication.

[1] The problem of "oiliness" was discussed in the first report, together with experiments by Albert Kingsbury at high rates of shear, and by M. D. Hersey on viscosity at high pressure. The latter results are available in detail in *Jl. Wash. Acad. Sci.*, vol. 6, pp. 525–530, 1916, while the report itself may be found in MECHANICAL ENGINEERING, vol. 41, June, 1919, p. 537. A second report, issued in December, 1921, may be obtained in pamphlet form from The American Society of Mechanical Engineers, 29 W. 39th Street, New York.

[2] The experiments have been resumed by Mr. Hersey at the Physical Laboratory of the U. S. Bureau of Mines, Pittsburgh, Pa.

[3] The kg. per sq. cm. or "atmosphere" is the unit almost universally found in high-pressure literature: it is about 14.2 lb. per sq. in., so that 1000 kg. per sq. cm. is approximately equivalent to 6.4 tons per sq. in. in the British system.

[1] *Jl. Wash. Acad. Sci.*, vol. 6, pp. 528 and 628, 1916.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A.S.M.E.

Résumé of the Month

A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulas or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Building Materials, Concrete A1-23. Tests of Heavily Reinforced-Concrete Slab-Beams. This paper presents the results of tests of 26 slabs, tested as simple beams, having four types of reinforcement. The slab beams were approximately 4 in. thick and $27^1/_2$ in. wide, and the four types of reinforcement consisted of (*a*) plain round bars laid direct between two supports, (*b*) expanded metal with the long dimensions of the diamonds parallel to the direction of the span, (*c*) plain round bars laid in two bands making 45 deg. with the direction of the span of the beam and 90 deg. with each other, and (*d*) plain round bars laid in one band making 45 deg. with the direction of the span.

The immediate purpose of the tests was to obtain data applicable to the design of slab members in concrete ships, and for this reason the slabs did not represent conventional design. This introduced difficulty in the interpretation of the test data, but several methods of interpreting the tests have led to conclusions which are in agreement with each other as to the general nature of the results.

On the whole the test results show a fair agreement with the analysis based upon the secant method of calculation. Expanded-metal reinforcement distributed the tension cracks in the concrete of the slab beams more uniformly throughout the length of the beam than did reinforcing bars laid direct between supports.

This Technologic Paper of the Bureau of Standards, No. 233, by Willis A. Slater and Fred B. Seely, may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Price, 15 cents.

Ferrous Alloys A1-23. Effect of Manganese on the Structure of Alloys of the Iron-Carbon System. A third Bureau of Standards Technologic Paper, No. 464, in the series on the Preparation and Properties of Pure Iron Alloys, has just been issued. It was prepared from experimental data collected by Messrs. Henry S. Rawdon and Frederick Sillers, Jr. This paper is concerned with the effect of manganese as a hardening element determined in an extensive series of alloys varying from 0 to 1.6 per cent carbon and 0 to 2 per cent manganese. Address Superintendent of Documents, Government Printing Office, Washington, D. C. Price 10 cents.

Fuel Utilization A4-23. Economic Combustion of Waste or By-Product Fuels. Because of the decreasing supply and increasing cost of high-grade fuels, the efficient utilization of those that are of low grade is becoming a problem of major importance to many industries and to the commercial progress of the nation. The data in this paper, consequently, are published as a contribution to the literature on the conservation of national resources. The term "waste fuel" as used in this paper means any combustible material that is not ordinarily included in the list of commercially marketable fuels.

David Moffat Myers prepared this bulletin which is known as Technical Paper 279 of the Bureau of Mines. Address Superintendent of Documents, Government Printing Office, Washington, D. C. Price 10 cents.

Hydraulics A1-23. Loss of Head in Valves and Pipes. A bulletin just issued by the Engineering Experiment Station of the University of Wisconsin on this important subject was prepared from experimental data gathered by Prof. Charles I. Corp and Roland O. Ruble of the University staff. The bulletin presents the results of 2200 tests on 48 different gate and glove valves. Results of 425 tests to determine pipe friction are also included.

Iron and Steel A4-23. Effect of Manganese on the Structure of Alloys of the Iron-Carbon System. See *Ferrous Alloys A1-23*.

Non-Ferrous Metals A2-23. Preparation of Light Aluminum-Copper Casting Alloys. A very large amount of experimental work on this subject has been conducted for the Bureau of Mines by Robert J. Anderson. His report which has just been received is known as Bureau of Mines Technical Paper 287. The author sums up his findings as follows:

Aluminum-alloy foundries in the United States employ three methods for introducing copper into aluminum in making light aluminum-copper alloys: (1) The use of copper directly; (2) the use of 33:67 copper-aluminum alloy; and (3) the use of 50:50 copper-aluminum alloy. The writer suggests that 60:40 copper-aluminum alloy might be suitable for the purpose. A suitable method for preparing rich alloys on a large scale is described in detail. The various methods used at different foundries have been compared.

This paper of 44 pages includes many micrographs and may be obtained for 10 cents from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Non-Ferrous Metals A3-23. Solder for Aluminum. Most of the metals commonly used in solders, except magnesium, are electropositive to aluminum. They therefore accelerate corrosion in the presence of moisture, and soldered joints of aluminum should be protected by varnish.

Various compositions of zinc-tin and zinc-tin-aluminum solders give the best results. This Circular of Bureau of Standards, No. 78 may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Price, 5 cents.

Paints, Varnishes and Resins A1-23. Moisture-Resisting Coatings for Wood. See *Forest Products A1-23*.

Paper A1-23. Study of Commercial Dial Micrometers for Measuring the Thickness of Paper. Specifications are given for a standard instrument. From a study of the mechanisms of instruments and the results of this investigation it is felt that two or more types of the mechanisms studied can be used in instruments that will meet the specifications. The paper also contains specifications for a standard procedure to determine the mean thickness of a sample of paper.

The Bureau of Standards Technologic Paper No. 226 was prepared by Messrs. P. L. Houston and D. R. Miller and may be secured from the Superintendent of Documents, Government Printing Office, Washington, D. C. Price 10 cents.

Petroleum and Allied Substances A1-23. Oil Shale—An Historical, Technical and Economical Study. In January, 1920, the State of Colorado and the U. S. Bureau of Mines entered into a coöperative agreement for the conduct of laboratory investigations on the oil shales of Colorado. Under this agreement a laboratory has been installed and equipped at the State University, Boulder, Colorado, and a research staff organized. It is the primary purpose of the investigational work to determine the most favorable conditions of retorting Colorado oil shales to yield the most of the best products from them.

This bulletin, known as No. 210 of the Bureau of Mines, was printed by the State of Colorado as part of the coöperative agreement. It represents the assembled results of the investigations up to the present, together with material of a general nature necessary in a well-rounded presentation of the present state of knowledge of the subject. Copies can be obtained from the U. S. Bureau of Mines, Boulder, Col.

Railroad Rolling Stock and Accessories A1-23. Properties of Chilled-Iron Car Wheels. Part II, Wheel Fit, Static Load, and Flange Pressure Strains—Ultimate Strength of Flange. This report, Bulletin No. 134, of the Engineering Experiment Station, University of Illinois, Urbana, Ill., prepared by Messrs. J. M. Snodgrass and F. H. Fuldner, presents two additional phases of the investigation of the properties of chilled-iron car wheels conducted at the University of Illinois. This investigation had for its object the determination of the strains which may occur within a car wheel and the limitations of present designs, with the view of improving the chilled-iron car wheel and making it more satisfactory under present and future service requirements. The work was done under a coöperative agreement between the Association of manufacturers of Chilled Car Wheels and the University. Price per copy, 40 cents.

Refrigeration A1-23. Specific Volume of Saturated Ammonia Vapor. Several years ago the Bureau of Standards began the determination of the various thermodynamic properties of ammonia to establish an experimental basis for engineering tables to be used in the refrigerating industry. The present paper is the last of a series of papers on the determination of those properties under saturation conditions.

The specific volume, or the numerical reciprocal of density, of the saturated vapor was measured in the temperature interval −50 to +50 deg. cent. by two methods; one a direct method and the other an optical method. Ammonia of high purity was used in all of the measurements.

This Scientific Paper of the Bureau of Standards, No. 467, by C. S. Cragoe, E. C. McKelvy, and G. F. O'Connor, may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Price, 5 cents.

B—Research in Progress

The purpose of this section of Engineering Research is to bring together those who are working on the same problem for coöperation or conference, to prevent unnecessary duplication of work, and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Fuels B1-23. Carbonizing Experiments on Lignite. As the result of a coöperative agreement between the Bureau of Mines and the Uni-

versity of North Dakota a series of experiments are being conducted at Grand Forks, N. D. on the carbonizing of lignite.

In conducting these experiments it was ever kept in mind that definite information was sought regarding a number of variables of unknown value and briefly, it was the aim to: (1) produce a well-carbonized lignite; (2) obtain a maximum throughout; (3) note the influence of the quality of lignite used on the performance of the oven and on the character of the carbonized product; (4) note the influence of the size of the lumps of lignite charged upon the character of product obtained and upon capacity; (5) eliminate the smoke nuisance; (6) study the performance of the cooler and the discharge apparatus ascertaining facts relative to its adaptability in preference to other types; (7) find out what the chief factors are that influence the production of a good quality of carbonized lignite, and make such changes in the oven structure as its operation indicated were necessary; (8) note the character, quality, yield and size of particles of the carbonized lignite produced; and (9) make certain laboratory studies during such delays in operation as are incidental to experimental work of this nature.

The program as outlined is being carried out, but on account of the fuel situation and other factors only a few different lignites have been tested. The same limitation applies to the study of the effect of sizes, but in spite of this fact the desired data relative to this factor are well in hand.

The results so far obtained are reported in the Bureau of Mines, Reports of Investigations, Serial No. 2441.

Heat Transmission B1-23. Heat Transmission Through Boiler Tubes. The effects of boiler scale, soot and oil upon the heat transmission through boiler tubes is the subject of an investigation being undertaken at the University of Illinois. Prof. A. C. Willard of the Department of Heating and Ventilation is conducting this research and Messrs. H. O. Croft and C. H. Cather are in direct charge of the experiments.

Instruments and Apparatus B2-23. Saybolt Universal Viscosimeter. A conference was held at the Bureau of Standards, November 14 with members of the American Petroleum Institute, as a result of which a committee of 5 members of the Institute was appointed to coöperate with the Bureau in expediting the more accurate standardization of the Saybolt universal viscosimeter.

The Institute and the Bureau are also coöperating with the Society of Automotive Engineers and the Interdepartmental Committee on Petroleum Products in the development of a numbering system for lubricating oils based on their viscosity.

Metallurgy and Metallography B1-23. Etching Reagents for Alloy Steels. The Bureau of Standards has been making a study of the problem of finding an etching reagent by which chromium carbide could be distinguished from vanadium carbide in a positive and satisfactory manner. Etching in a hot solution of potassium permanganate and sodium hydroxide for one minute darkens chromium carbide to a strong brown-red or brown color, while vanadium carbide remains uncolored and apparently unattacked. Another but less positive means of distinction is that obtained by electrolytic etching with a weak current in a dilute aqueous solution of ammonia or sodium hydroxide. The chromium carbide is eaten out, leaving a dark brown-red or brown cavity, while the vanadium carbide is eaten out apparently at a slower rate, leaving cavities which appear light.

F—Bibliographies

The purpose of this section of Engineering Research is to inform the profession of bibliographies which have been prepared. In general this work is done at the expense of the Society. Extensive bibliographies require the approval of the Research Committee. All bibliographies are loaned for a period of one month only. Additional copies are available, however, for periods of two weeks to members of the A.S.M.E. These bibliographies are on file at the headquarters of the Society.

Corrosion F1-23. Protective Metallic Coatings for the Rustproofing of Iron and Steel. A selected bibliography on corrosion of iron and steel and its prevention by metallic coatings forms an appendix to Bureau of Standards Circular No. 80. Apply Superintendent of Documents, Government Printing Office, Washington, D. C. Price 20 cents.

Petroleum and Allied Substances F1-23. Oil Shale—an Historical, Technical and Economic Study. A new bibliography dated July, 1922, forms an appendix to Bulletin No. 210 of the U. S. Bureau of Mines. It has been made as short as possible, consistent with the presentation of literature that covers oil shale from all angles. Address U. S. Bureau of Mines, Boulder, Colorado.

CORRESPONDENCE

Contributions to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities and policies of the Society in Research and Standardization.

Velocity of Steam in Pipes

To the Editor:

In an abstract on page 190 of Mechanical Engineering for March, 1923, there is raised the question of steam velocity in pipes.

In a paper on The Flow of Fluids Through Commercial Pipe Lines, by Wilson, McAdams, and Seltzer [*Jl. Ind. & Eng. Chem.*, vol. 14, p. 105 (1922)], the fact is brought out and supported by experimental results that the friction factor f in Fanning's equation is a function of DvS/z, where D = inside diameter of pipe in inches, v = average linear velocity in pipe line in feet per second, S = specific gravity of fluid, and z = viscosity in centipoises. Given a knowledge of these factors, any pipe-line problem for any fluid can be solved.

The difficulty in applying this equation to the flow of steam is our lack of knowledge of its viscosity. While the temperature coefficient of viscosity is known for several other gases, an extensive search of the literature has shown only a few determinations for steam at room temperature and 100 deg. cent. It would seem that this would be an interesting problem for the physics department in a university. The determinations should be made up to a temperature of 600 deg. cent., and at least three points taken between 400 deg. and 600 deg. The data up to 400 deg. cent. will probably follow a different law from those above 400 deg. Above the critical temperature (375 deg. cent.) Sutherland's equation for the temperature coefficient of viscosity may be expected to apply. The apparatus should be calibrated with air.

It would certainly be very desirable to add a better knowledge of the viscosity of steam to that of the other properties which are being so carefully worked out. Any one desiring to take this matter up will find a complete bibliography on the general subject in Bingham's recent book on Viscosity and Fluidity.

What is needed is not more empirical formulas, but the facts to put a fundamentally correct formula on a working basis.

After the experimental work on viscosity has been done by a physicist, then a careful correlation of the existing data should be undertaken by an engineer.

Geo. H. West.

San Francisco, Cal.

Mathematical Determination of the Modulus of Elasticity

To the Editor:

The writer feels gratified at the interest aroused by his proposed method of bending tests with thin strips, published in the December issue of Mechanical Engineering, as evidenced by the much appreciated comments of Prof. Wm. R. Bryans in the February issue, and of Messrs. E. A. Richardson and S. Timoshenko in the April issue.

While acknowledging the correctness of the writer's deductions, Professor Bryans asserts that the basic equation, $M = EI/\rho$ correctly applies only to infinite radii of curvature, and for finite values of ρ the results obtained can only be approximate.

To the writer's knowledge there is no such limitation in regard to ρ; the only assumptions underlying the above equation are: (1) The neutral plane of the loaded beam passes through the center of gravity of the given cross-section; and (2) the modulus of elasticity E is the same for expansion and compression. Here is the simple deduction of this basic equation: As seen in Fig. 1, the length

of the fiber element a-a before the beam is bent is $\rho d\alpha$; when the beam is bent its length becomes $(\rho + e)d\alpha$; therefore its relative expansion (or contraction, if situated below the neutral line) is:

$$\frac{(\rho + e)d\alpha - \rho d\alpha}{\rho d\alpha} = \frac{e}{\rho}$$

The fiber tension at the point a of the cross-section m-m will therefore be $E\frac{e}{\rho}\ dA$, where A denotes the cross-sectional area of the beam. Its moment M relative the axis O of the cross-section is $E\frac{e^2}{\rho}\ dA$, which, extended to all fibers of the cross-section, will be $\frac{E}{\rho}\ \Sigma e^2 dA = \frac{EI}{\rho}$, or $M = EI/\rho$. No limitation as to the magnitude of ρ enters into this deduction. Mr. Timoshenko makes the same statement, but the deduction is given here in full, for the sake of clearness.

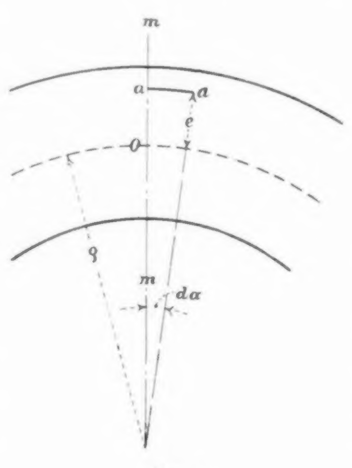


Fig. 1

Mr. Richardson in his comments very ably shows the possible effect of an error in the computation of I, the moment of inertia, concluding, as does also Professor Bryans, that the proposed method is far from mathematical precision.

Extending Mr. Richardson's method of calculation to the area $A = bh$ of the cross-section of the strip, the difference in the error percentages is—

$$\frac{dI}{I} - \frac{dA}{A} = \frac{db}{b} + 3\frac{dh}{h} - \left(\frac{db}{b} + \frac{dh}{h}\right) = 2\frac{dh}{h}$$

Here all depends on the thickness h and the measurement variation dh, both controllable factors. While the question as to how correctly a measurement may be taken may not properly be argued, it nevertheless must be conceded that even if the proposed method be not considered as an unconditional substitute for existing laboratory methods, it surely affords a sound practical expedient. Theoretically the chief point of interest of the method is its novelty: it makes possible for the first time the exact integration of the differential equation of the elastic curve, without the customary approximation of assuming $[1 + (\partial x/\partial y)^2]^{1.5} = 1$; also the determination of the cord tension of an archer's bow when the modulus of elasticity of the bow material is known.

The disadvantage of employing I instead of the cross-sectional area may be compensated by the large and easily measurable deformations in this method. This may account for the fact that in the two recorded tests with thin wooden strips, using a pocket rule and an ordinary spring balance, the results obtained were so near those given in engineering tables.

Mr. Timoshenko in his extensive and instructive comments considers the limitation imposed by the elastic limit and determines analytically and by certain experimental data the influence of the cross-sectional deformations on the bending of thin strips, showing how the above-mentioned basic equation may be made theoretically more correct by the introduction of a certain coefficient.

With regard to the elastic limit, attention is here called to the fact that in the bending-test device for thin strips illustrated in the December issue, provision is made for easily verifying in each test whether the bending is within or outside the elastic limit, without the need of any calculations, thus affording the possibility of its experimental determination; though some preliminary idea as to what the radius of curvature is likely to be near the elastic limit, as shown by Mr. Timoshenko, is naturally desirable.

As to the coefficients m and k introduced by Mr. Timoshenko to account for cross-sectional deformations, we are here on uncertain ground, but it may be of interest to note that this simple bending-test device for thin strips readily lends itself to the determination of these coefficients. As the differential elastic-curve equation has been integrated without any assumed approximation and the equations obtained are theoretically exact—in the absence of influencing cross-sectional deformations—and all factors are directly measurable, with the exception of E, the modulus of elasticity, which may either be taken from existing tables or determined directly by means of an extensometer, therefore all factors in these equations will be known except the said coefficients, which could accordingly be determined.

It would be gratifying if Mr. Timoshenko would publish a detailed description of his bending experiments with thin strips.

David Guelbaum.

Syracuse, N. Y.

Second Revision of A.S.M.E. Boiler Code, 1923

A HEARING is held by the Boiler Code Committee at least once in four years, at which all interested parties may be heard, in order that such revisions may be made as are found to be desirable, as the state of the art advances. The year 1922 became the period of the second revision and the Boiler Code Committee held a Public Hearing in connection with the recent Annual Meeting of the Society in December, 1922, to which the membership of the Society and every one interested in the steam-boiler industry was invited to attend and present their views.

For the convenience of every one interested, a printed schedule of the various proposed revisions had been published and distributed to all those who were invited to attend the Public Hearing and the opportunity was given thereat for the most careful consideration of all of the proposed revisions. As a result of the suggestions received at the Public Hearing, a number of modifications of the previously announced revisions were offered and in addition suggestions were received for still further revisions of the Code. All of these suggestions for modifications and new revisions have been carefully considered by the Boiler Code Committee and the result in modifications of revisions and additional revisions are here published.

It is the request of the Committee that these revisions be fully and freely discussed so that it may be possible for any one to suggest changes before the rules are brought to final form and presented to the Council for approval. Discussions should be mailed to C. W. Obert, Secretary to the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be considered by the Boiler Code Committee.

The revisions here published are limited to the paragraphs appearing in the 1918 Edition of the A.S.M.E. Boiler Code, and the paragraph numbers refer to the paragraphs of similar number in that edition. For the convenience of the reader in studying the revisions, all added matter appears in small capitals and all deleted matter in smaller type in brackets.

Modifications of Revisions

Par. 9 REARRANGE PARAGRAPH AS PRINTED IN JULY 1922 AND APRIL 1923 ISSUES OF MECHANICAL ENGINEERING AS FOLLOWS:

9 The use of bessemer steel is prohibited for the pressure parts of boilers. When the maximum allowable working pressure exceeds 160 lb. per sq. in., cross-pipes connecting the steam and water drums of water-tube boilers, headers, cross-boxes and all pressure parts of the boiler proper over 2-in. pipe size, or equivalent cross-sectional area, shall be of wrought steel, or cast steel of Class B grade, as designated in the Specifications for Steel Castings. Malleable iron may also be used when the maximum allowable working pressure does not exceed 200 lb. per sq. in., provided the form and size of the internal cross-section perpendicular to the longest di-

Note: Matter in caps—added matter; Matter in smaller type in brackets—to be deleted.

mension of the box is such that it will fall within a 7-in. by 7-in. rectangle.

Seamless tubes or lap-welded pipe may be used for drums or other pressure parts of a boiler provided such tubes or pipes conform to the specifications for welded and seamless steel and wrought-iron pipe, and provided also that the outside diameter of the tubes or pipes does not exceed 20 in.

PAR. 21 REPLACE REVISED FORM PRINTED IN APRIL 1923 ISSUE OF MECHANICAL ENGINEERING WITH THE FOLLOWING:

21 *Tubes* AND NIPPLES *for Water-Tube Boilers.* *a* TUBES AND NIPPLES FOR USE IN WATER-TUBE BOILERS FOR ALL PRESSURES IN EXCESS OF 160 LB. ALLOWABLE WORKING PRESSURE SHALL BE SEAMLESS STEEL. UP TO AND INCLUDING 160 LB. PRESSURE LAP-WELDED STEEL OR IRON MAY BE USED.

b The maximum allowable working pressures for steel or wrought-iron tubes OR NIPPLES used in water-tube boilers shall be for the various diameters and MINIMUM gages measured by Birmingham wire gage, as given in Table 2. REDRAWN PIPE NOT TO EXCEED $1^1/_2$ IN. STANDARD PIPE SIZE WHICH MEETS THE PIPE SPECIFICATION MAY BE USED FOR WATER-TUBE BOILERS FOR A WORKING PRESSURE NOT TO EXCEED 200 LB. PER SQ. IN., WHEN SCREWED IN THE SHEET, PROVIDED THE WALL THICKNESS IS AT LEAST 50 PER CENT GREATER THAN THE MINIMUM WALL THICKNESS REQUIRED BY TABLE 2. THE MAXIMUM ALLOWABLE WORKING PRESSURE FOR COPPER TUBES OR NIPPLES USED IN WATER-TUBE BOILERS, SHALL BE FOR THE VARIOUS DIAMETERS AND MINIMUM GAGES MEASURED BY BIRMINGHAM WIRE GAGE AS GIVEN IN TABLE $2^1/_2$, BUT NOT TO BE USED FOR PRESSURES TO EXCEED 250 LB. COPPER TUBES SHALL NOT BE USED WITH SUPERHEATED STEAM.

TABLE 2 CHANGE HEADING TO READ AS FOLLOWS:

Table 2 Maximum Allowable Working Pressures for Steel OR WROUGHT-IRON Tubes OR NIPPLES for Water-Tube Boilers.

TABLE $2^1/_2$ CHANGE HEADING AS GIVEN IN APRIL 1923 ISSUE OF MECHANICAL ENGINEERING AS FOLLOWS:

Table $2^1/_2$ Maximum Allowable Working Pressures for Copper OR WROUGHT-IRON Tubes OR NIPPLES for Water-Tube Boilers.

PAR. 185 REPLACE REVISED FORM PRINTED IN DECEMBER 1922 AND APRIL 1923 ISSUES OF MECHANICAL ENGINEERING WITH THE FOLLOWING:

185 When shell plates exceed 5/8 [$^9/_{16}$] in. in thickness in horizontal-return-tubular boilers, the portion of the plates forming the laps of the circumferential joints, where exposed to the fire or products of combustion, shall be planed or milled down as shown in Fig. 8, to a thickness of not over 9/16 [$^1/_2$] in. provided the requirement in Par. 184 is complied with. Where plates are planed or milled down it shall be for the entire circumference of the joint, and the fillet at the edge of the planing MAY [shall] be not less than 1 in. radius.

PAR. 230 INSERT THE FOLLOWING BEFORE THE ADDED MATTER GIVEN IN THE DECEMBER 1922 ISSUE OF MECHANICAL ENGINEERING:

SLING STAYS, IF USED BETWEEN CROWN BARS AND BOILER SHELL OR WRAPPER SHEET, SHALL BE PROPORTIONED SO AS TO CARRY THE ENTIRE LOAD WITHOUT CONSIDERING THE STRENGTH OF THE CROWN BARS.

PAR. 253 REPLACE FIRST SECTION OF REVISED FORM IN DECEMBER 1922 ISSUE OF MECHANICAL ENGINEERING WITH THE FOLLOWING:

ALL HOLES IN BRACES, LUGS AND SHEETS FOR RIVETS OR STAYBOLTS SHALL BE DRILLED FULL SIZE WITH PLATES, BUTT STRAPS AND HEADS BOLTED UP IN POSITION, OR THEY MAY BE DRILLED OR PUNCHED NOT TO EXCEED $^1/_4$ IN. LESS THAN FULL SIZE FOR PLATES OVER $^5/_{16}$ IN. IN THICKNESS AND $^1/_8$ IN. LESS THAN FULL SIZE FOR PLATES NOT EXCEEDING $^5/_{16}$ IN. IN THICKNESS AND THEN DRILLED OR REAMED TO FULL SIZE WITH PLATES, BUTT STRAPS AND HEADS BOLTED UP IN POSITION.

PAR. 257 ADD THE FOLLOWING TO THE REVISED FORM GIVEN IN DECEMBER 1922 ISSUE OF MECHANICAL ENGINEERING:

OR SPLITTING THE CALKED SHEET.

PAR. 259 REPLACED REVISED FORM GIVEN IN JULY 1922 ISSUE OF MECHANICAL ENGINEERING WITH THE FOLLOWING:

259 A manhole reinforcing ring, when used, shall be of WROUGHT OR CAST steel [or wrought iron], and shall be at least as thick as the shell-plate thickness required by Par. 180.

PAR. 278 INSERT THE WORDS "WITH BEVEL SEATS," AFTER THE WORDS "INTERMEDIATE LIFT" AT THE END OF THE SEVENTH LINE OF THE MATTER GIVEN IN THE APRIL 1923 ISSUE OF MECHANICAL ENGINEERING.

PAR. 325 REVISE SECOND SENTENCE OF REVISED FORM IN JULY 1922 ISSUE OF MECHANICAL ENGINEERING AS FOLLOWS:

The shearing and crushing stresses on the rivets OR STUDS used for attaching the lugs or brackets shall not exceed 8 per cent of the strength given in Pars. 15 and 16.

PAR. 332 OMIT NEXT TO LAST SECTION OF REVISED FORM GIVEN IN APRIL 1923 ISSUE OF MECHANICAL ENGINEERING BEGINNING WITH "PORTABLE BOILERS OF 100 HP."

PAR. 333c REPLACE REVISED FORM GIVEN IN APRIL 1923 ISSUE OF MECHANICAL ENGINEERING WITH THE FOLLOWING:

c On traction, portable or stationary boilers of the locomotive type or Star water-tube boilers—on the furnace end, above the handhole. Or on traction boilers of the locomotive type—on the left wrapper sheet forward of the driving wheel. IN ADDITION TO THE STAMPINGS HEREIN PROVIDED, PORTABLE BOILERS OF 100 HP. OR LESS SHALL, WHEN POSSIBLE, HAVE THE STAMPING HEREIN PROVIDED APPLIED ON A NON-FERROUS PLATE 3 IN. × 4 IN. IN SIZE WHICH SHALL BE AS NEARLY AS PRACTICABLE, IRREMOVABLY FASTENED TO THE BOILER NEAR THE WATER-COLUMN CONNECTIONS.

New Revisions

PAR. 17 REVISED:

Thickness of Plates. The minimum thickness of any boiler plate under pressure shall be $^1/_4$ in. THE MINIMUM THICKNESS OF PLATES IN STAYED SURFACE CONSTRUCTION SHALL BE $^5/_{16}$ IN.

PAR. 184 ADD THE FOLLOWING SECTION:

d THE DISTANCE FROM THE CENTERS OF RIVET HOLES OF CIRCUMFERENTIAL JOINTS TO THE EDGES OF THE PLATE SHALL NOT BE LESS THAN THE DIAMETER OF THE RIVET HOLES.

PAR. 190 REVISED:

190 A HORIZONTAL-RETURN-TUBULAR BOILER SHALL NOT HAVE A CONTINUOUS LONGITUDINAL JOINT OVER 12 FT. IN LENGTH. With butt and double strap construction longitudinal joints of any length may be used, provided the tension-test specimens are so cut from the shell plate that their lengthwise direction is parallel with the circumferential seams of the boiler, and the tests meet the standards prescribed in the specifications for boiler-plate steel.

PAR. 219 REVISED:

219 When stay rods are screwed through the sheets and riveted over, they shall be supported at intervals not exceeding 6 ft. In boilers without manholes, stay rods over 6 ft. in length may be USED WITHOUT SUPPORT if screwed through the sheets and fitted with nuts and washers on the outside PROVIDED THE LEAST CROSS-SECTIONAL AREA OF THE STAY ROD IS NOT LESS THAN THAT OF A CIRCLE 1 IN. IN DIAMETER.

PAR. 263 REVISED:

263 The minimum width of bearing surface, for a gasket on a manhole opening shall be 11/16 [$^1/_2$] in. No gasket for use on a manhole or handhole of any boiler shall have a thickness greater than $^1/_4$ in. WHEN COMPRESSED.

Revisions on Miniature Boiler Code

M-19 REVISE FIRST SECTION TO READ:

M-19 All boilers referred to in this section shall be plainly marked with the manufacturer's name, maximum allowable working pressure, which shall be indicated in arabic numerals, followed by the letters "lb.," and serial number. All boilers built according to these rules shall be marked A.S.M.E. Std.—Miniature. Individual shop inspection is [not] required for miniature boilers IN THE SAME MANNER AS FOR POWER BOILERS.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities Papers and Proceedings of

The American Society of Mechanical Engineers

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Technical Literature

IN A RECENT ISSUE of the *Carnegie Technical Journal*, Prof. W. Trinks directs attention to the dearth of good technical books which give information about the various specialties of engineering. He traces the reason for this to the fact that the compensation received by authors is not sufficient to attract competent men. What books are written, are written for altruistic reasons or to achieve a reputation. Textbooks dealing with fundamentals are of course in a different class. Furthermore, the progress of engineering art and science is so rapid that technical books become obsolete at an alarming rate. He draws attention to the paucity and inadequacy of engineering libraries in the country, and points out the large number of good technical books in foreign tongues.

Professor Trinks' statements serve to emphasize the value of the technical press and the proceedings of the technical societies, both of which present valuable information concerning current developments. The intelligent clipping and indexing of this material should therefore be the duty of the alert practicing engineer. The monthly and annual printed indexes of engineering literature, such as the Engineering Index in Mechanical Engineering, should be of inestimable value in this respect. In view, therefore, of this value of current engineering literature, does it really seem necessary that time should be spent on specialized technical books which become obsolete quickly and yield but a relatively small compensation to the author?

Exception would probably be taken by many American engineers to Professor Trinks' high opinion of foreign books. The fact remains, however, that foreign printing costs and the attitude of foreign engineers are conducive to a greater volume of good technical books of the specialized type.

As to American engineering libraries, satisfactory facilities are provided in most of the large cities. New York, Boston, Pittsburgh, Cleveland, Chicago, and Washington all possess adequate collections of technical books which are available for reference. Recently Denver has taken steps to establish an engineering library.

The photostat service of the Engineering Societies Library aims to provide desired information where it is not possible to send out the book or periodical in which it appears. At the present time it is the practice of the Library to loan duplicate copies of its books to members of the National Engineering Societies, and obviously a helpful step in this respect would be the broadening of this loan service.

A.E.S.C. Completes Sixth Year of Successful Service

THE increasing scope and influence of the American Engineering Standards Committee as a clearing house for engineering and industrial standardization is shown by the 1923 Year Book of this organization. Its success should be extremely gratifying to those who originated the committee in 1917 with a view to coördinating the standardization work of the national engineering societies. From its humble start with four coöperating bodies it now reports 23 member bodies, 205 participating agencies with duly accredited representatives and 917 individuals engaged in committee activities. And the end is not in sight, for the possibilities of industrial development through standardization and simplification are unfolding in a manner that has led the A E S C (without punctuation), as it desires to be designated, to develop a new financial policy whereby industrial organizations may become sustaining members and contribute directly to the work.

The success of this Committee's activity is due to the fundamental principle of procedure by which the A E S C as an organization does not initiate projects but rather administers and forms policies for the carrying out of the work. The actual work of securing agreement on standards falls to the sectional committees, organized by the national societies and associations which accept sponsorship for them. The A E S C participates by determining whether the work should be undertaken, by designating the sponsors, and by ultimately approving the result as an "American Standard" or a "Tentative American Standard."

The sectional committees are organized to assure representation of all interests, and the project is initiated with a conference which brings all of the conflicting ideas together and affords an opportunity for ironing out differences.

The A E S C has a very broad function in its coöperation with foreign national standardization bodies. Progress has been made in ball-bearing standardization, different proposals having been presented to various foreign bodies as the basis for international agreement.

This coördinated standardization movement has passed through many vicissitudes. However, its present firm establishment gives ample assurance that the important function which it is to perform will be carried out in a manner entirely worthy of the engineering profession.

State Rights and Water Power

THE recent correspondence between the Governor of New York and the Governor of Pennsylvania on state water-power rights bids fair to become classic. Governor Smith of New York holds out for state rights in the water power from navigable streams and proposes to develop the water powers of his state for the exclusive use of New York. Governor Pinchot agrees with the engineering conclusion that interconnected systems are necessary for cheap, reliable hydroelectric power. His words, which we quote below, are worthy of careful consideration.

> After eighteen years of study and work on this problem, I have come confidently to expect the growth of a nation-wide interlocking power system........The freedom of commerce among the several states, the unrestricted exchange across state lines of service, goods and resources, guaranteed by the Federal Constitution, is the strongest man-made basis of the prosperity of each state. This consideration applies not only to energy riding in a coal car but equally to energy flowing over a wire, whether the burning of fuel or the falling of water was the source. Furthermore, really cheap power cannot be supplied to consumers unless the burning of coal and the flowing of water contribute their energy to a common reservoir for the common supply of industries, farms, homes and railroads. Such a system must transcend state lines and is likely to become nation-wide.

In the meantime, Massachusetts is planning to analyze the power needs of its growing industries, and the Associated Industries of Massachusetts have selected Charles T. Main, Past-President of The American Society of Mechanical Engineers, as chairman of a committee to determine the kinds and amounts of present powers, the cost of each, and the increase in that cost in the last ten years; the available new sources of power both within and without the borders of the state, the probable demand for such power, and the cost of supplying it to the industries and public utilities of the commonwealth of Massachusetts.

Business Cycles and Unemployment

Report of Committee Appointed by Secretary Hoover Suggests Methods for Preventing Widespread Unemployment During Periods of Depression

THE report of the committee appointed in September, 1921, by Secretary of Commerce, Herbert Hoover, to investigate the problem of unemployment as related to the fluctuations of the business cycle, has been made public. The committee, after stating the questions to be considered, discuss the nature and effects of the business cycle at some length, using the term to describe the series of changes in business conditions which are characterized by an upward movement toward a boom, followed by a downward movement into depression. As a result of their analysis of the problem the committee arrive at a number of conclusions which they embody in a series of recommendations relating both to the direct prevention of expansion and inflation and to the prevention of unemployment. The outstanding features of these recommendations are presented in the following extracts from the report.

Collection of Fundamental Data. In many industries the coöperation necessary to form a common pool of fundamental facts is made possible through trade associations, to which current figures are reported by their members. In other industries such figures, in whole or in part, are supplied directly to Government bureaus. In an endeavor to put in more available form the sum of information now current and to add to it Secretary Hoover has established in the Department of Commerce a monthly survey of current business which summarizes the data available from all sources that bear upon this major problem of business trends.

What is evidently needed is an increase in the resources of the Department of Commerce and a larger degree of coöperation with the department in coördinating and extending business information, so that business men and bankers may know promptly the facts about the rate of production measured in physical units, the stocks on hand and in transit, the trend of prices, the volume of sales, and the trend in money rates. There is great need also for recording data as to the speed of freight movements so as to show whether the output of farms and factories is being promptly distributed to the consumer or is being delayed in transit because of freight congestion.

Larger Statistical Service. The committee recommend the expansion and standardization of the statistics now collected by state and federal bureaus, the publication of employment statistics by the Federal Bureau of Labor Statistics, and the final summation and publication of all of these statistics by the Department of Commerce, in order that there may be promptly available a connected, uniform series of facts about the trend of business.

In collecting figures on stocks and production the following list of commodities has been suggested to the committee by experts as most significant in showing the trend of the business cycle:

1 Raw wool and woolen textiles
2 Raw cotton and cotton textiles
3 Hides and leather and shoes
4 Iron and steel and leading fabricated products, such as structural steel and standard tools
5 Zinc, lead, and copper and leading products of each
6 Bituminous coal.

Research. A primary necessity is the collection and dissemination of fundamental data. Following this, we need further development of special research into economic forces, into business currents, and into broad questions of economic method. Industries generally recognize the need of research in physical science. Laboratories have been equipped with large staffs of trained workers. A similar recognition of the importance of economic research and the interpretation of economic facts would be the beginning of better control of business conditions by business men.

The forecasting of probable business trends is difficult and can never be undertaken successfully by any kind of public institution, except in a limited field. Business men must themselves form their own fundamental judgments when adequate data are furnished. Research as to the effect of different trends and economic forces is, however, a different problem from forecasting. Such research should be carried on continuously by the Government bureaus, because the data available to these bureaus are more extensive than those available to other institutions, which must depend upon published summaries of Government data.

Control of Credit Expansion by Banks. The individual banker, like the individual business man, may properly be asked to assume some measure of responsibility. If only in his own interest, his policies should be determined by the general business situation as well as by the apparent soundness of the particular transactions his customers ask him to finance. One suggestion is that when prices are rising and business is expanding, bankers should ask borrowers to maintain an increasing ratio of quick assets to current liabilities.

Control of Inflation by the Federal Reserve System. The Federal reserve banks now hold, as a result of the World War, a much larger amount of gold than would suffice to support all of the credit which American industry and agriculture can possibly need on anything like present price levels. With the return of more prosperous conditions in Europe a considerable part of this gold will naturally leave us. Meanwhile this excess gold might become the basis of a disastrous inflation of our domestic credit, which would be followed by an even more disastrous collapse when the gold goes out. This is the problem which faces us in the development of the Federal reserve system to its maximum usefulness, and it is a problem worthy of most careful and thorough study by bankers and associations of bankers.

Control by Business Men of the Expansion of Their Own Industries. The committee have seen numerous instances in which the individual business man, by conducting his business with reference to the business cycle, has avoided dangerous overextension of inventories and fixed capital which in many other instances resulted in unemployment and business failure during the cycle just past.

Planning production in advance and with reference to the business cycle, laying out extensions of plant and equipment ahead of immediate requirements with the object of carrying them out in periods of depression and carrying through such construction plans during periods of low prices in conformity with the long-time trend, the accumulation of financial reserves in prosperity in order to mark down inventories at the peak, and the maintenance of a long view of business problems rather than a short view, will enable firms to make headway toward stabilization.

Control of Private and Public Construction at the Peak. One method by which periods of expansion might in part be controlled is through the cessation and postponement of construction by the Government, railroads, public utilities, and private owners in boom periods when prices are high. Reserves built up in periods of high earnings and expansion are then spent for construction during periods of depression. When this policy is more generally followed it will be of peculiar value, as it will tend to keep low the ratio of fixed investment to productive capacity, to the great advantage of industry.

Holding back public works and private construction for periods of depression not only gives employment to large numbers of workers when it is most needed, but creates a demand for raw materials for construction which in turn stimulates other industries to offer employment. It maintains the buying power of those directly or indirectly employed, it creates a market for goods, and enables the workers, directly or indirectly employed to buy the products of other industries. Finally, construction work in a period of industrial depression, when costs are lower, is economical.

The essential steps in any general program are to plan construction work, private or public, long in advance with reference to the cyclical movement of business, and in the case of public works to pass the necessary legislative appropriations when facts about the trend of business show that it is sound policy to spend money for such purposes.

Public Utilities. In the interest both of utilities and of the buying public it is obvious that the normal time to finance new construction or improvements in public utilities is in periods of depression, when interest charges are reasonable and costs of construction low. In so far as the managers of utilities and public-service commissioners can regulate construction in order to fill up the valleys and lower the peaks of the business cycle they will aid in alleviating the extremes of the cycle, and by means of their economies they will keep their capital investment from unnecessary expansion, to the advantage both of the utilities and of the public.

Unemployment Reserve Funds. Nothing is more demoralizing for wage earners than the feeling of insecurity of employment. Unemployment and the fear of unemployment are powerful causes of discontent. The idea of employer, employee, or both, contributing during periods of employment to a reserve fund under separate or joint control to help sustain the worker when unemployed in periods of depression and to equalize and stabilize his purchasing capacity merits consideration.

Employment Bureaus. We do not regard an employment service a shaving a direct and immediate effect upon the business cycle. We do believe that if such employment bureaus are organized throughout the country, their reports will show the demand for labor and the number of workers seeking positions and will therefore be another measure of business conditions. If employment bureaus are organized effectively enough to insure transfer from one position to another with the least possible loss of time, they will make labor more immediately available and thus prevent loss of production for the employer and loss of income for the wage earners, thus helping to maintain the level of purchasing power.

The personnel of the committee signing the report is as follows: Owen D. Young, chairman of the board, General Electric Co., chairman; Joseph H. Defrees, former president United States Chamber of Commerce; Mary Van Kleeck, Russell Sage Foundation; Matthew Woll, vice president, American Federation of Labor; Clarence M. Woolley, president American Radiator Co.; Edward Eyre Hunt, secretary of the President's Conference on Unemployment, secretary.

In its work, the committee received the assistance of appropriations toward its cost from the Carnegie Foundation and services contributed by the National Bureau of Economic Research, the Russell Sage Foundation, the Federated American Engineering Societies, the United States Chamber of Commerce, the American Federation of Labor, the American Statistical Association, the American Economic Association, the Bureau of Railway Economics, the Department of Commerce, and a number of other bodies.

Hydroelectric Power for the Metropolitan District

Availability, Cost, Service Requirements, Operating Difficulties, and Transmission Problems Discussed at Meeting of the New York Sections of National Engineering Societies

THE New York sections of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers held a joint meeting in the Engineering Societies Building, New York, on March 21, at which five speakers discussed the economical use of hydroelectric power for the New York-New Jersey Metropolitan district. The presiding officer was Calvert Townley, chairman of the New York Section A.I.E.E., who emphasized the vital need of an adequate future supply of power for this district and the importance of focusing on this need the attention of all engineering societies.

Coördinated Statement of the Problem

F. W. Scheidenhelm,[1] cited the principal obstacles to the use of hydroelectric power in the Metropolitan district as:

1 Limited information, or, more accurately, limited appreciation of the extent to which hydroelectric power could be made available and of the method of utilizing such power, especially in combination with steam-electric power

2 Uncertainty or disagreement as to the relative cost of delivered hydroelectric power compared with the cost of steam-electric power performing the same service

3 Doubt as to the quality of service on part of hydro plants and of connecting transmission lines

4 Legal difficulties, involving especially the means for acquiring necessary lands and rights, and

5 Lack of definite and continuing policy on part of the states concerned.

Colonel Scheidenhelm pointed out that the problem was essentially one of using hydroelectric power in combination with large sources of steam-electric power supply. He called attention to the fact that greater hydro capacity was installed under combined hydro and steam operation than if the same water power were to be developed to serve an independent market. He also pointed out that the utilization of hydro power would introduce financial economies because fixed charges on investment for steam development averaged from twenty to forty per cent more than for hydro. A greater use of water power would ease congestion on railroads.

For the combined systems, such as would obtain in the Metropolitan district, there would be the increased assurance of continuous service which resulted from diversity of sources of power supply. Thus the possible ill effects of labor difficulties at the coal mines, on the railroads, or in the steam-electric power plants themselves would be considerably mitigated as compared with systems relying entirely on steam-electric power.

Greater New York and Westchester County were separable from northeastern New Jersey only on political, not economic, grounds. The Hudson River was not a barrier in itself. It happened that on each side of the river the power market was such that it could independently utilize large quantities of hydro power, whether high-load-factor power from the Niagara and the St. Lawrence or low-load-factor power from an interior stream. Nevertheless, it was clear that in order to obtain the fullest benefits from the use of hydro power, state boundaries should not be allowed to become barriers to proper economic development.

Availability and Cost of Delivery

W. S. Murray[2] presented facts as to the availability of water power and cost of delivery. He referred to the Superpower Survey published in 1921 as a "formula of procedure" for unified development.

He considered three rivers as hydroelectric possibilities at or within two hundred miles from the metropolitan load centers—the Hudson, the Delaware, the Susquehanna. The maximum number of kilowatt-hours must be provided from these developments to reduce unit cost, and in this connection the impounding of waters of reservoirs was very important. The total capacity already developed in the Susquehanna was 83,500 kw. which should be increased in 1930 by approximately 100,000 kw. In an average year such a development would produce 1,230,000,000 kw-hr. In more distant years, using the total available head of 204 ft., a total capacity of 620,000 kw. would be justified. The Delaware River was fundamentally a storage river. As of 1930 it would appear to be economical to develop 350,000 kw., producing during an average year 1,250,000,000 kw-hr. at a cost at the river of slightly more than 6 mills. The Hudson also offered valuable storage opportunities which could be economically developed to 150,000 kw. as of 1930 with an average yearly capacity of 900,000,000 kw-hr. at a cost at the river of slightly under 6 mills.

Mr. Murray also stated that the low development costs on the Niagara and St. Lawrence made it possible to place electric energy within the Metropolitan load center at less cost than from the Hudson. In concluding, he stated the results of a recent intensive investigation that a combination of steam and hydroelectric energy could be developed within a radius of one hundred miles and delivered into the existing distribution systems at a cost not exceeding 7 mills, provided the load factor of the delivered power did not fall below 65 per cent. A bulk of 500,000 kw. could be made available in two years and increased to twice that amount if desired.

Service Requirements

George A. Orrok[3] outlined the service requirements which hydroelectric power must meet. He emphasized the importance of reliable service and outlined the severe operating conditions in the Metropolitan district. He estimated that in 1930 the output in the Metropolitan district would probably run between ten and twelve billion kilowatt-hours with a peak lying between two and one-half and three million kilowatts. In closing, Mr. Orrok discussed the price at which hydro powers were attractive as follows: Mr. Murray had mentioned 7 mills as the probable selling price of hydroelectric power delivered at the outskirts of the district. If there was added to this the connection cost of 2.5 mills, we could roughly approximate the condition under which this current might be utilizable by the power companies. With coal at $8 a ton and a 60 per cent load factor, a price of 6 to 7 mills delivered at the district boundary seemed to be, roughly, about the point where the hydroelectric ceased to be attractive. With coal at a lower price or water which must of necessity be given a higher load factor, the limit of attractive price would be lower. Even at the figures given, the water seasonal variation must work in well with the district variation or there would be no economic advantage. The figures which he gave had been based on using as much water on the peak as possible, but even with this condition the night watch must waste water unless large diurnal storage was provided.

Factors Affecting Quality of Service

F. A. Allner,[4] from his experience in the operation of the Holtwood Plant on the Susquehanna River, told of the factors that affected quality of service. Ice trouble seemed to him the most important hydraulic trouble to guard against. This might be of three kinds, local, up-river, and frazil ice, the latter being the most dangerous. This could be eliminated by maintaining the highest possible temperature in the power house, by continuous movement of guide-vane mechanisms, and by steam or electric heating of submerged metal parts where the ice was inclined to stick. Mr. Allner compared the service troubles in the highly complicated steam plant with its complicated auxiliary apparatus with the hydro plant with its few sturdy and easily repaired parts. He also emphasized the ability of the hydroelectric plant to take on its load quickly. At the Holtwood plant a water-wheel unit was brought from standstill to full load in 21 sec.

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[1] Consulting engineer, New York, N. Y.

[2] Consulting engineer, New York.

[3] Consulting engineer, New York. Mem. A.S.M.E.

[4] General superintendent, Pennsylvania Water and Power Co., Baltimore. Mem. A.S.M.E.

Lorin E. Imlay[5] discussed the reliability of long-distance transmission and pointed out that long-distance service was growing better from year to year, relating his experience in transmitting current from Niagara Falls over about 200 miles of overhead circuits.

In the discussion which followed, John P. Hogan[6] advanced the thought that not only should state boundaries be disregarded in water-power development, but perhaps national boundaries ought not to be considered. He stated that the only distant powers that might be economically used in the Metropolitan district were those that were practically continuous and could be delivered in the city at a relatively high load factor. He also emphasized the importance of considering each stream by itself and of a policy of uniform progressive development of that stream.

W. S. Finlay[7] summarized the problem of the Metropolitan district as the necessity of determining the character of the service it considered necessary to its welfare and comfort, recognizing the cost to be paid, and then bending every energy to the conservation of its resources and the development of such resources as affected its power service and supply.

Progress in Fatigue of Metals Investigation

During the year 1922, definite and important progress was made in the experimental work of the Fatigue of Metals Investigation at the Engineering Experiment Station of the University of Illinois. Engineering Foundation has continued its coöperation and the committee of the National Research Council has advised on program and report. A second report giving results and conclusions in detail is on the press as Bulletin No. 136, of the Experiment Station. This report, in slightly condensed form, will be printed also in the annual publication of Engineering Foundation, to be ready for distribution in May.

Interest in this investigation has spread and its practical value has come to be more widely appreciated. During 1922 outside funds for support of the project came wholly from the General Electric Company. Its officers have expressed high satisfaction with the work done.

Extension for two years is assured by the provision of additional funds to the amount of $30,000. The University of Illinois, the National Research Council and Engineering Foundation will continue to coöperate. The following industries will participate financially and in other ways: General Electric Company by a substantial addition to its preceding investment of $30,000; the Allis-Chalmers Manufacturing Company, the Copper and Brass Research Association, representing the most important producers and manufacturers of copper and its alloys, and the Western Electric Company. Several other companies are expected to join, in addition to a number mentioned in the first report (Bulletin No. 124, of the Engineering Experiment Station), which contributed materials and services of considerable value.

On the new part of the program are tests of steels at high temperatures, such as obtain in modern steam-engineering equipment and in internal-combustion engines, and a study of non-ferrous metals, particularly the copper alloys.

The investigation continues under the immediate charge of Prof. H. F. Moore and has the general supervision of Prof. Arthur N. Talbot, as the head of the Department of Theoretical and Applied Mechanics, in the Engineering College of the University of Illinois.

Small-Motored Planes

The newspaper reports of the gliding competition in France on April 1 state that the winner made four flights in a glider fitted with a seven-horsepower auxiliary motor. One of the flights lasted a quarter of an hour and a speed of ninety kilometers per hour was attained—a unique performance. The accounts are not sufficiently explicit to enable a judgment to be formed as to the real value of the flights, but enough has been made known to emphasize the possibilities of planes driven by small motors as an economical and popular means of locomotion.

[5] Consulting engineer, Niagara Falls Power Co.

[6] Consulting engineer, William Barclay Parsons, New York.

[7] Vice-president, American Water Works & Electric Co. New York, Vice-president A.S.M.E.

A.S.M.E. Meeting at Montreal to be Popular

Montreal, where the Spring Meeting of The American Society of Mechanical Engineers will be held, has the requisites needed to insure the success of the gathering; excellent hosts, a good technical program, and interesting excursions. The meeting will start on Monday, May 28, will continue for four days, and will be participated in by the members of the Engineering Institute of Canada. The technical sessions will be held at the Engineering Institute Building and at the Mt. Royal Hotel, the headquarters hotel of the meeting.

Two sessions will be devoted to Hydroelectric Power. There will also be sessions dealing with Management, Railroads, Port Development, Textiles, Fuels, and Machine Shop Practice. The afternoons will be set apart for visits to points of historic and scenic interest about Montreal, and on Tuesday and Wednesday evenings there will be novel entertainments. The Montreal Branch of the Engineering Institute of Canada is providing the entertainment for a smoking concert on Tuesday evening, and on Wednesday evening there will be a dinner dance at the Mt. Royal Hotel.

Plans are under way for an excursion by boat from Toronto to Kingston for those who come from points west and southwest of Buffalo, and an automobile trip is being arranged for those who care to drive from New York and the New England district. Following the meeting there will be excursions to Grand Mere, Shawinigan Falls, and Quebec. All indications point to a well-attended, enthusiastic meeting.

The details of the meeting to date have appeared in the *A.S.M.E. News* and complete particulars of the final program will be given in the issue of April 22.

"The Four C's Guide Post"

At a recent meeting of the New York Railroad Club, E. K. Hall, vice-president of the American Telephone and Telegraph Company, spoke on the need for team play in our industrial organizations. Every man in the company must want to make the enterprise a success and be willing to do his share, whatever that may be, to attain that object. Mr. Hall did not believe that a successful formula had been found, but he did tell about what he called "The Four C's Guide Post" which may be explained in his own words, as follows:

"*Contact:* We start on the theory that one of the first things we have got to do is to get some contact between the management and the men. The men have been separated—separated geographically, and separated by an organization chart that starts with the president and, by the time it gets down to the man in the ranks, is way down in the depths. He could not go up that steep ladder if he was a steeple climber. We have got to find some means to get the people together—the management and the men.

"*Conference:* Getting them together is not enough. You get them acquainted, acquainted so they know each other. How do you get acquainted with a man? You do not get acquainted with him until you talk to him a little bit. He tells you what he thinks and you express an opinion and you size each other up, and that is the way you get acquainted. You are not acquainted when a man says, "Mr. A, meet Mr. B." That is contact, but not acquaintance. We say you have got to have something more than contact, you have got to have conference, you have got to talk things over. That is the second C.

"*Confidence:* Assuming you have a reasonably good bunch of people in the industry you are engaged in, if you talk together long enough and discuss things long enough and interpret yourselves to each other, that will inspire confidence. Then you are getting somewhere.

"*Coöperation:* The minute the men have confidence in the management and the management begins to have confidence in the men—and you cannot have one without the other, because the men are not going to have a whole lot of confidence in a manager who does not know them—it is very easy to coöperate, and that is the fourth C. That is team play. That is what we have got to have in the industry."

The Federated American Engineering Societies

Coal-Storage Survey

PROBABLY no decision reached by the Executive Board of American Engineering Council at its meeting in Cincinnati, Ohio, March 23 and 24, 1923, deserves higher commendation than that relating to a coal-storage survey. An authoritative statement covering the engineering, chemical, and economic factors involved in the storage of coal, and the influence of those factors on storage at the mine and by various classes of consumers, should be of prime importance in solving the complex coal situation. Many have contended that the widespread practice of storing coal by consumers would materially reduce the intermittent aspect of the coal industry; would result in an ample supply of coal at all times; would even up the demand for transportation facilities; would enable a larger resort to water transportation; would reduce operating and transportation expenses, and therefore would lead to a reduction in the cost of coal to the consumer. The compilation and analysis of complete data on all of the important factors involved should form a report as valuable as that on the Elimination of Waste in Industry.

In forming the committee to undertake the work the F.A.E.S. proposes that each of the following groups shall be represented: Bituminous and anthracite coal mining, transportation, public utilities, Bureau of Mines, equipment, chemical engineering, and any others that may be able to contribute scientific and fundamental information. W. L. Abbott, chief operating engineer, Commonwealth Edison Co., Chicago, has been chosen as chairman of the committee, which will develop its own plans, direct the investigation, employing the necessary assistance, and prepare the report.

The plan has the full endorsement of Secretary Hoover, Dr. George Otis Smith, vice-chairman of the U. S. Coal Commission, Mr. Wadleigh, U. S. fuel administrator, and Dr. H. Foster Bain, director of the Bureau of Mines. The work of the Department of Commerce and the Coal Commission, which are studying other features of the coal industry, and that of the F.A.E.S. committee will be so coördinated as to avoid duplication, confusion, and conflict. It is hoped that the report may be completed not later than November 1, 1923.

Storrs Plan of Domestic Coal Storage

EARLY in March, in a conversation with the Executive Secretary of the F.A.E.S., John Hays Hammond, chairman of the U. S. Coal Commission, voiced the desire of the commission for the coöperation and assistance of the engineers of the nation in its work and suggested a line of specific activity. Mr. Hammond emphasized the importance of coal storage and stated that it is a more difficult task to secure the storage of domestic coal than that of coal purchased by large users. He proposed a movement for a larger storage of domestic coal and urged that the engineers of the country lend their support to such a movement.

If engineers will point out to their clients and employers the advantages, accruing both to the public and to the coal industry, which can be secured if coal is stored during the summer, it is believed that they will be willing to arrange for the domestic coal purchases of their employees.

The plan which he advocated, one which has particularly impressed the Coal Commission, was devised by L. S. Storrs, of the Connecticut Company, New Haven, Conn. Under that plan the employee submits to his employer, prior to April 1, an estimate of his winter fuel needs. Delivery is to be made at the option of the retail dealer during the six months following. Full payment for the coal will be made by the company at the time of delivery. The company is reimbursed by deducting the cost of the coal from the employee's salary in monthly instalments over the six months' period.

Under this plan the employer purchases the coal at the best possible price and secures delivery early in the season. The employees, many of whom are accustomed to buying coal in very small lots during the period of highest prices and distribution difficulties, can make substantial savings and be assured of a sufficient quantity of coal.

Mr. Hammond's suggestion was transmitted immediately to the liaison officers of the member societies and, while at the time of writing reports of action taken are not available, a large number of inquiries from individual engineers and from companies as to details of the Storrs plan have been received at F.A.E.S. headquarters. Several large companies propose to adopt the Storrs plan or some similar method. Officials of the Department of Commerce, the Coal Commission, and the Bureau of Mines interested in the problem of coal storage have all expressed approval of the plan, and in many quarters it has been enthusiastically received. It is hoped that engineers will lend their fullest support to the movement.

Cincinnati Meeting of the Executive Board

IN ADDITION to the coal-storage decision, the Executive Board took action on a number of important matters at its Cincinnati meeting, and a number of interesting progress reports were presented. The Committee on Transportation, authorized at a meeting of the Committee on Procedure in February, had made a preliminary survey of the problem of transportation and advocated coöperation with a number of national organizations which have been working on it for some time. The Executive Board approved that policy. Max Toltz, of St. Paul, is chairman of the committee.

The Board voted to assist in the movement to bring about uniform safety legislation. In a statement on this subject issued recently by the F.A.E.S., both state and national legislation are recommended. Congress is asked to enact safety laws providing for the safe construction and equipment of buildings, regular inspecton of conditions, and the training of employees to observe proper precautions against accidents. The statement points out that "although the U. S. Employees' Compensation Commission is now expending approximately $3,000,000 per annum to alleviate the results of industrial accidents, it has no authority to take action of a preventive nature which might obviate the necessity for this expenditure and the loss of life and limb which it connotes." The F.A.E.S. also recommends the adoption by the several states of uniform legislation, and will support the plan of the National Safety Council for Conservation Week.

Concerning the registration of engineers it was resolved that "American Engineering Council should continue to collect and keep up to date a record of the Engineers' Registration and Licensing Laws that may be proposed or passed, together with decisions thereunder, for the use of the constituent societies of the F.A.E.S. and others, but that it assumes no control over the actions of such constituent societies in regard thereto."

The Board also voted to study the question of constituting the American Engineering Council a clearing house on elimination of waste, to endorse the plan for Government reorganization, to broaden the program of its Reforestation Committee, and to further American participation in the proposed world power conference in London in 1924.

Report of the Secretary

Secretary Wallace presented a detailed report, an interesting feature of which was a résumé of services rendered by the F.A.E.S. to various engineering societies, groups of engineers, organizations, and individuals during recent weeks. It has supplied information on the formation of engineering organizations, secured speakers for different groups, suggested men for important engineering positions, and provided full information on registration of engineers, uniform traffic regulation, provisions for housing workers, and other matters of importance.

He announced that the report on the Elimination of Waste in Industry is to be published in German by the Masaryk Academy of Czechslovakia, which is a government agency, and circulated in Czechoslovakia, Austria, and Germany, and quoted the president of the Academy as stating that the report is "one of those very few real contributions toward reconstruction of the postwar world."

Engineering and Industrial Standardization

Voluntary Adoption of Standards of Quality[1]

AMONG numerous topics of interest to the manufacturers and merchants of the United States contained in the Annual Report of Secretary of Commerce Hoover for the year 1922, there is one to which I particularly desire to invite your attention. Under the heading Voluntary Establishment of Grades and Qualities, Secretary Hoover has the following to say:

> Agitation has been current for many years for the extension of the Federal laws to the establishment of grades and qualities of different commodities. The lack of such established grades and standards of quality adds very largely to the cost of distribution because of the necessity of buying and selling upon sample or otherwise, and because of the risk of fraud and misrepresentation, and consequently the larger margins in trading. It was considered by the department, however, that it would be infinitely better if such grades and qualities could be established voluntarily in the trades themselves instead of by legislation, and policed by trade associations as in the case in several old-established trades. To this end a number of conferences have been held in different branches of the lumber, textile, paper and other trades. The service of the department has been to bring the different branches of the trade, the manufacturers, wholesalers, retailers, and representatives of larger consumers' associations together and to develop committees of different branches of trades. The plan has been generally welcomed and applications have been received from many trades for such assistance. The expert services of the Bureau of Standards, Bureau of Foreign and Domestic Commerce, and the other bureaus of the department have been brought into service for technical advice in these matters, and results of important bearing upon the improvement of business ethics and cheapening of distribution have been attained.

This topic of voluntary action of business men to establish definite grades for various lines of merchandise should be of especial interest to the organization members of the National Chamber. Shoe manufacturers, textile manufacturers, and others have been worried by snap-judgment proposals to set up so-called "pure shoe" and "pure fabric," etc., standards by Government action. Of course, the reputable American business man is not afraid or unwilling to sell his goods on reasonably drawn specifications or to stand back of the quality of his product to a reasonable extent. There is nobody better qualified to pass on what is and what is not reasonable as a standard of quality or performance than those who are in the trade itself. Here, as Secretary Hoover points out, is undoubtedly a field for voluntary action on the part of producers, manufacturers, and merchants in establishing grades and setting standards of quality or performance, with which the consumers will be sympathetic.

Business is facilitated and the ground for commercial disputes between buyer and seller is narrowed down if sales are made on the basis of standard grades of merchandise, perfectly familiar to both buyer and seller. In a good many foreign countries there has been loss of good will for particular American dealers as well as some lingering prejudice to the good name of American business generally, which can be traced to the lack of understanding and agreement between buyer and seller as to the qualities entering into transactions, or to the absence of standards of quality and performance. When such standards exist, backed up by the moral force of a trade association or trade group in the United States, the promotion of the sale of American merchandise of a given kind and the building of good will toward American trade abroad are made easier, and rest upon a sound foundation.

Standardization, and the setting up of systems of inspection and certification in some cases, have made most progress among lines of raw material and foodstuffs sold in bulk and moved in large amounts. The full possibilities of doing business on standards of quality have not yet been realized, even in many such lines of merchandise. It is, of course, not only in the foreign trade, but in the whole wide range of domestic trade that the use of clear standards, easily checked up, may be developed. The American Society for Testing Materials, and many other organizations represented in the American Engineering Standards Committee are making great progress in setting up and improving national standards on engineering products. The applicability of the same principles to numerous lines of manufactured specialties is well worthy of consideration by trade associations and chambers of commerce.

Some commercial and trade associations not only set up standards but go further and provide rules and facilities for inspection and certification of merchandise. Costs must be kept down. With all due recognition of this fact, however, where actual inspection and certification of individual shipments do not add disproportionately to the costs of merchandise, and do serve a useful purpose, associations may well consider the possible desirability of making some arrangements, either with existing bureaus, laboratories, or other agencies doing commercial work of sampling, inspecting, testing, and certifying, or of actually setting up such accommodations if they do not exist adequately for the needs of the particular industries as those needs grow.

Our department managers in the different departments of the staff of the Chamber of Commerce of the United States are desirous of coöperating with any organization undertaking or extending this class of work. We have been in touch with some of the organizations that have gone far in this direction. The book of rules for trading in all sorts of oil products, adopted by the Interstate Cotton Seed Crushers Association may be cited as an example of association work on definitions of grade and quality, sampling, testing, fixing variation, performance of contract, etc., which would probably be a revelation to those not in the trade. We want more information concerning the extent to which other associations have gone to date in the adoption of voluntary standards and the enforcement of those standards. And, further, we want an indication from our members as to the ways in which our Natural Resources Production Department, our Fabricated Production Department, our Domestic Distribution Department, our Foreign Commerce Department, or the departments dealing with insurance, finance, and transportation can be of assistance in furthering this movement. We are in touch with the Government bureaus chiefly concerned and are working directly with some national organizations in getting their standards known in foreign countries.

[1] From an open letter to American business men by Julius H. Barnes, President, Chamber of Commerce of the U. S.

Report of the Director, Bureau of Standards

THE 1922 Report of the Director of the Bureau of Standards which has been recently made available in pamphlet form ($5^3/_4$ by 9 in., 282 pages) contains much of interest to engineers whether they are engaged in manufacturing, sales, or pure engineering. The following paragraphs taken from the early pages of the report will serve to emphasize the important service which the Bureau of Standards is able and anxious to render to the public and to industry.

> The bureau compares with its own standards of measurement the standards and measuring instruments of states, cities, scientific laboratories, educational institutions, and the public. In this way the standards of the National Government are made available to every one in the country. For these comparisons a nominal fee is charged, except in the case of national and state government institutions. The bureau is at all times glad to assist these institutions in matters concerning these standards or their use, whether it be in connection with the enactment of laws, regulations, or ordinances concerning the weights and measures of every-day trade or in connection with precision standards used in scientific work.
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> It must not be inferred from the above that the bureau's activities are devoted principally to the interests of the user or consumer. The fundamental facts regarding standards of measurement, quality, or performance are the very things which most deeply concern manufacturers; they are fundamentally concerned, either directly or indirectly, with the improvement of methods of production or the quality of the output. It may be said that the bureau occupies somewhat the same position with respect to the manufacturing interests of this country that the bureaus of the Department of Agriculture do to the agricultural interests. Many industries realize the importance of scientific investigation which, in practically every case, involve some kind of precision measurement.
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> During the past year the bureau has continued its close coöperation with American industries. It has continued to act as a clearing house for fundamental, scientific, and technical information, and manufacturers are coming to realize more and more that they can often secure from the bureau general and sometimes even specific advice concerning improvements in their particular industrial processes. The solution of many difficult problems in the industries cannot be reached in commercial plants, but requires the work of a specially equipped research laboratory, working always in close coöperation with manufacturers who are the best judges of the practical aspects of the problem.
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> One of the greatest services which the bureau performs for the industries is the training of men for scientific and technical research work. Many young men receive what is, in some respects, better than a postgraduate

course by working in some of the minor scientific positions at the bureau during the years immediately following the completion of their college course. These men then go into the industries with a better conception of the problems of research work.

National Conference Votes for Safety Code on Walkway Surfaces

A CONFERENCE attended by sixty-three representatives of trade associations, technical societies, safety organizations, and Government departments, held in New York recently, declared by unanimous vote that "It is desirable to have a nationally uniform safety code on walkway surfaces" and that the development of this code should be carried out under the procedure of the American Engineering Standards Committee.

The conference voted to include in the code elevator floors, elevator landings, corridor floors, ramps, runway floors, stair treads and landings, fire-escape treads and landings, floors around machinery and at door thresholds, and sidewalk hazards such as coal-hole covers and sidewalk doors. It was recommended that the sectional committee consider the question of platforms in front of electrical apparatus, especially switchboards and floors around machinery in motion, as to insulation and non-slip qualities. This new code will apply to apartment houses, factories, and other working places, office buildings, hospitals, hotels, and restaurants, railway cars, railway stations and train platforms, schools and theaters.

At a meeting of the Main Committee of the A.E.S.C. held since this conference the American Institute of Architects and the American Society of Safety Engineers were designated as joint sponsors for this project. These sponsors will organize the sectional committee which will draft the code. This sectional committee as usual will be composed of official representatives of all organizations concerned with the subject of safe walkway surfaces, either as producers, consumers, casualty underwriters, or governmental officials representing the general public.

Protection of Heads and Eyes

A SECOND edition of the National Safety Code for the Protection of the Heads and Eyes of Industrial Workers has been issued in pamphlet form. The arrangement of the code is such as to first present the general requirements, including a classification of the occupations which require eye protection. Then follow the detailed requirements for each group of occupations, operating rules, and finally the specifications for tests which must be met to insure that protectors will adequately fulfil their purpose.

Following is a discussion of the rules intended to assist the reader in understanding the reasons for the rules and in interpreting the rules, and to give suggestions for the best means of carrying them out.

E.I.C. Elects Successor to President St. Laurent, Who Recently Died

WALTER J. FRANCIS, consulting engineer of Montreal and senior vice-president of the Engineering Institute of Canada, has been elected president to fill the unexpired term of Arthur St. Laurent, who died early in March. Mr. St. Laurent, who assumed office in January, was born in Rimouski, Quebec, in 1859. He was graduated from Montreal University, and in 1888 entered the service of the Public Works Department of Canada, remaining in government service all his life and rising to the position of chief engineer of the department. Among the operations over which he had charge was the construction of the dam at St. Andrews Rapids on the Red River; the building of a traffic bridge across the North Saskatchewan River at Edmonton, where he introduced concrete in bridge construction; the lengthening of the dry dock at Levis, Quebec; and the construction of the Laurier bridge at Ottawa and the grain elevator No. 1 at Montreal Harbor.

Mr. St. Laurent's successor is a graduate of the University of Toronto. He was engineer for the royal commission of inquiry into the Quebec bridge disaster and reported on the wreck, developing in detail the theory for the collapse. His consulting work has included designs and reports on many hydroelectric and steam power plants, investigations and reports on buildings, especially foundations, and municipal investigations.

Facts Favoring Railway Electrification

MANY articles have been written comparing steam and electric motive power for railroads. Generally they state that electric power permits more rapid acceleration, that stand-by losses are reduced or eliminated, large overloads can be handled for short periods, smoke is eliminated, coal and water stations are not needed, locomotive coal need not be hauled, less coal is used, etc. On the other hand it is shown that when steam power is used, intricate and interdependent power-distribution facilities are not required, capital expenditures are reduced, no trouble is caused by inductive interference or electrolysis, and so on. All these statements are generally accepted as facts, but it is unfortunate that most of them of necessity are qualitative rather than quantitative. For example, it is variously estimated that electric operation will save all the way from 10 to 70 per cent of the annual coal bill. Actual figures in one case indicate the saving to be 28 per cent, but even these figures are open to criticism. It is for this reason that we welcome such facts as the following: Electric locomotives on the Chicago, Milwaukee & St. Paul are used to haul trains on continuous runs of 440 miles except for station stops; switching locomotives on the New York, New Haven & Hartford are kept in continuous service 24 hours a day for more than 70 per cent of the total time without being shopped for even minor repairs, while road engines frequently make 500 miles a day and average 33,000 miles per locomotive failure; multiple-unit cars on the Pennsylvania operate with an average of over 48,000 car-miles per detention. A recently issued statement also announces that several of the 41 passenger locomotives which have been in service for 16 years have now been run more than 1,000,000 miles. Facts like these do two things: establish the dependability of electric equipment and make easier the decision of the road wishing to determine whether or not it should adopt electric operation. (*Railway Age*, Mar. 24, 1923, p. 795)

Civil Engineers Vote Against Joining Federation

A BALLOT of the membership of the American Society of Civil Engineers on joining The Federated American Engineering Societies, canvassed on April 6, 1923, showed a total vote of 5753, of which 3641 were opposed to joining the Federation. The results of the ballot, tabulated by districts, are as follows:

	District	Yes	No
1	Foreign	25	84
	Territory within 50 mi. of N. Y. Postoffice	166	688
2	New England, New Brunswick, and Nova Scotia	84	331
3	New York (except as included in District 1) and Quebec	107	221
4	Eastern Pennsylvania, New Jersey (except as included in District 1), and Delaware	143	292
5	District of Columbia, Maryland, and Virginia	134	254
6	Western Pennsylvania, West Virginia, and Ontario	87	214
7	Michigan, Wisconsin, Iowa, Minnesota, Manitoba, North and South Dakota	276	144
8	Illinois	167	186
9	Indiana, Kentucky, and Ohio	184	154
10	Alabama, Florida, Georgia, Mississippi, North and South Carolina, and Tennessee	109	203
11	Colorado, New Mexico, Arizona, Southern California, Utah, and Wyoming	191	189
12	Idaho, Montana, Washington, Oregon, Alaska, Alberta, British Columbia, Saskatchewan, and Yukon Territory	102	124
13	Northern California and Nevada	84	209
14	Missouri, Arkansas, and Louisiana	108	158
15	Nebraska, Kansas, Oklahoma, Texas, and Mexico	145	200
		2112	3641

The Efficiency of The Scotch Marine Boiler

THE captions for Figs. 7 and 8 in Mr. Jefferson's paper on The Efficiency of the Scotch Marine Boiler, published in the April issue of MECHANICAL ENGINEERING, were, through error, interchanged. The higher-efficiency curve is for the forced-draft test, while the lower values are for the induced-draft test. Photographs of all the burners used in the test were submitted with the original article. The selection of illustrations was made by the Editor.

Meetings of Other Societies

American Railway Engineering Association

Standardization and labor economics were leading topics under discussion at the twenty-fourth annual meeting of the American Railway Engineering Association held in Chicago, March 13–15, 1923. J. L. Campbell, of the El Paso & Southwestern Ry., in his address as retiring president of the association, spoke at some length upon the problem of labor economics, and in regard to standardization emphasized the need of a wider use of adopted standards of design and practice. Both he and R. H. Aishton, president of the American Railway Association, called attention to the large amount of standardization work essential in railway engineering. The Committee on Standardization recommended close coöperation with the work of the American Engineering Standards Committee. The matter was discussed by many of those present but no definite action was taken. The Association is at present represented on the A.E.S.C. by one member, through the American Railway Association.

The Committee on Economics of Labor considered the problems of obtaining and retaining labor, and organizing labor for efficient and economical work. This committee is considering methods of organizing forces for maintenance work and submitted a report of preliminary studies outlining methods of renewing rails and ties.

The Rail Committee presented statistics of rail failures, revealing a deterioration of quality of rail in the 1916 and 1917 rollings. The number of failures per 100 track-miles during five years' service ranged above 200 for the rails rolled about 1910, while subsequent improvement of quality brought the failures of 1914 rail down to 74. The latter figure increased to 105 for 1916 rail. Preliminary service indications for the rollings of 1918 and subsequent years indicate renewed improvements.

Final specifications for the erection of railway bridges were presented and adopted, and highway-bridge specifications for bridges less than 300 ft. span were presented.

Following a discussion of the need for participation by engineers in the revision of the Interstate Commerce Commission's schedule of accounts for railways, it was voted that the association, in connection with the American Railway Association, take prompt action to bring the engineering requirements of an accounts schedule to the attention of the commission.

The Committee on Water Service discussed the relative merits of cast iron, steel, wood, and other materials for pipe lines, the Committee on Yards and Terminals presented a comprehensive study of the principles affecting the design of passenger stations for main-line traffic, and other committees gave reports on additional phases of railway engineering.

Edward H. Lee, president and chief engineer, Chicago & Western Indiana R. R., was elected president for 1923–1924. E. H. Fritch was reëlected secretary.

American Management Association

A conference of nearly two hundred executives, representing industrial and commercial enterprises in all parts of the country, was held in New York on March 14, 1923, to organize the American Management Association. This new organization takes the place of the National Personnel Association, which was formed last year through the merger of the National Association of Corporation Training and the Industrial Relations Association of America. It will be devoted exclusively to the consideration of the human factor in commerce and industry.

Among the speakers at the meeting were Charles R. Hook, vice-president and general manager of the American Rolling Mill Co., Middletown, Ohio, and Howard Coonley, President of the Walworth Manufacturing Co. Mr. Hook stressed the necessity of close and friendly coöperation between the heads of industrial enterprises and the workers in order that better conditions, social and economic, may be brought about. He stated that the problem of industrial America is not just more production, but more units of production per man per day. One part of the problem, he continued, deals with improved machinery to reduce the number of men needed per unit of product and the other affects individual efficiency and reward. Mr. Coonley discussed the correlation of sales and production.

The officers of the new association are: President, W. W. Kincaid, president of the Spirella Co., Niagara Falls, N. Y.; Vice-Presidents; Sam A. Lewisohn, New York, vice-president of the Miami Copper Company, John A. Stevenson, vice-president of the Equitable Life Assurance Society of the United States, New York, and Fred W. Tasney, vice-president of the Prudential Insurance Company of America, Newark, N. J. Mr. Lewisohn, who presided at the business meeting, issued a statement in behalf of the officers and directors of the association, as follows:

> Personnel work is an integral, inseparable part of management interwoven into all of the efforts and activities of the production and sales departments and of the office. It cannot be segregated as an isolated function, and all efforts to bring about such a separation are foredoomed to failure. There is ample experience to prove this sweeping statement.
>
> This meeting was designed to present to executives two important phases of the problem in which the Association is interested. It is believed that the consideration of the human side of management as an integral part of the whole will lead to a more permanent acceptance of the idea. Incidentally it will provide greater opportunity for the personnel man and an increasingly complete interpretation of the management problem with adequate recognition to the most important factor—the human factor—in commerce and industry.

American Boiler Manufacturers' Association

The American Boiler Manufacturers' Association held its winter meeting in New York on Feb. 12, 1923. Following an address by the president, A. G. Pratt, vice-president of the Babcock & Wilcox Co., E. R. Fish, representative of the association on the A.S.M.E. Boiler Code Committee, reported progress in the work of that committee, and a letter from Charles E. Gorton, chairman of the Uniform Boiler Law Society, reporting the progress of boiler legislation in several states, was read.

Papers on Budgeting, by G. S. Barnum, of the Bigelow Co., and on the Standardization of Bolt, Nut, and Rivet Proportions, by F. G. Cox, weer presented. Mr. Barnum's paper emphasized the value of an accurate method of cost accounting to the manufacturer.

W. C. Connelly presented the report of the Committee on Related Industries, and summarized the replies to a questionnaire on boiler rating which had been sent out to the entire membership of the association. About 45 replies were received; of these 7 preferred to rate the boilers by horsepower, 24 by square feet of heating surface, and 11 by both heating surface and horsepower. The manufacturers of water-tube boilers were the only ones to present a unity of opinion on the use of 10 sq. ft. per hp.; the others varied from 7.5 to 12, the greatest difference being in the small sizes of locomotive and vertical-type boilers. On the question of including integral economizer surface as part of the boiler heating surface, 19 firms favored treating this as a separate item, while 4 considered that it should be treated as boiler heating surface.

Reports on a conference with the Department of Commerce on Standardization and Simplification, and on the work of the National Board of Boiler and Pressure Vessel Inspectors were also presented.

American Chemical Society

The 65th meeting of the American Chemical Society was held at New Haven, Conn., during the week of April 2, 1923. Sessions were held by all the divisions and sections except the leather and fertilizer divisions. The papers presented numbered over 350, and covered such subjects as agricultural and food chemistry; petroleum, gas, and fuel chemistry; motor fuels; industrial and engineering chemistry; cellulose chemistry; rubber chemistry; chemical education; history of chemistry; biological chemistry; sugar chemistry; physical, inorganic, organic, and dye chemistry; water, sewage and sanitation; and the chemistry of medicinal products.

Historical, educational, and industrial exhibits were given, and inspection trips made to a number of manufacturing plants in New Haven and neighboring cities, and to various laboratories at Yale University. One day was devoted to the dedication of the Sterling Chemistry Laboratory.

Speakers at general meetings included James R. Angell, president of Yale, Brigadier General Amos A. Fries, Chemical Warfare Service, U. S. War Department, Arthur D. Little, Boston, Mass., Francis P. Garvan, president of the Chemical Foundation, and Sir J. J. Thomson, F.R.S.

LIBRARY NOTES AND BOOK REVIEWS

Accurate Tool Work. By C. L. Goodrich and F. A. Stanley. Second edition. McGraw-Hill Book Co., New York and London, 1923. Cloth, 6 × 9 in., 300 pp., illus., diagrams, $3.

A collection of articles written by the authors or selected from the *American Machinist*, which discuss practically, methods and devices for producing accurate, interchangeable machine parts.

Briquetting. By Albert L. Stillman. Chemical Publishing Co., Easton, Pa., 1923. Cloth, 6 × 9 in., 466 pp., illus., $6.

This is the first American work on the subject of briquetting, and is based, the author states, on many years' experience. The book opens with an account of the raw materials, which is followed by a chapter on briquet presses. Succeeding chapters describe the methods for briquetting various materials, such as steel swarf and turnings, cast-iron borings, non-ferrous metals, wood waste, peat, lignite, coals, flue dusts and ores. Binders are also discussed. Bibliographies and lists of patents on each subject are given.

Car Builders' Cyclopedia. 1922. Tenth edition. Locomotive Cyclopedia. 1922. Sixth edition. Simmons-Boardman Publishing Co., New York, 1922. Cloth, 9 × 12 in., nearly 1200 pp. a vol., illus., diagrams, $8 per vol.

These two works have long been valued for the definite, thorough description of current American practice in the construction and repair of railroad rolling stock which they present. Each opens with a dictionary of the terms used, following this by a series of chapters which present drawings and photographs of contemporary equipment of all kinds, with brief descriptive articles on development and present practice. Specifications of the American Railway Association, Government regulations and safety rules are given.

The present editions offer the text in a new arrangement, by which the information on each broad topic is collected in one chapter instead of being scattered through the book under specific headings as in previous editions. The new arrangement will, it is thought, facilitate reference to the books.

Design of Machine Elements. By James A. Mease and George F. Nordenholt. First edition. McGraw-Hill Book Co., New York and London, 1923. Cloth, 6 × 9 in., 237 pp., diagrams, tables, $2.50.

Most textbooks on this subject are too comprehensive, in the opinion of the authors of this one, to be suitable for an elementary course. To overcome this difficulty they present the present text which makes no claim to originality of subject-matter except in the methods of computing gear pitches, but which is new in scope and in its manner of presentation. The book is the outgrowth of notes originally prepared by Prof. P. B. de Schweinitz for use at Lehigh University.

Design of Steam Boilers and Pressure Vessels. By George B. Haven and George W. Swett. Second edition. John Wiley & Sons, New York; Chapman & Hall, London, 1923. Cloth, 6 × 9 in., 435 pp., illus., diagrams, charts, tables, $4.

This book is intended primarily to teach rational methods of boiler design, while at the same time it is intended to be an introduction to the study of machine design, a purpose for which the authors believe an analysis of the stresses existing in boilers and other pressure vessels has many advantages.

In general, the results here presented have been obtained by rational rather than empirical methods, the usages of current boiler-making practice having been kept constantly in view. Many graphs and tables are given which enable numerical results to be obtained without using formulas. The principles are illustrated by their application to the complete practical design of boilers and tanks of six different types.

Dictionary of Applied Physics. Vol. 3, Meteorology, Metrology and Measuring Apparatus. By Sir Richard Glazebrook. Macmillan & Co., New York and London, 1923. Cloth, 6 × 9 in., 839 pp., illus., 63s.

The third volume of this dictionary maintains the high standard of excellence shown in the first two volumes. It should be of interest to engineers in all branches of the profession, as it contains accurate scientific data and precise theoretical information on measuring instruments and methods of measurement. Among the important articles are: Surveying Tapes and Wires, by Sidney W. Attwell; Preparation of Quartz Fibers, by Charles V. Boys; Nomography, by Selig Brodetsky; Physics of the Atmosphere, by David Brunt; Measurement of Solar Radiation, by William W. Coblentz; Watches and Chronometers, by E. G. Constable; Design of Scientific Instruments, by Horace Darwin and Cecil C. Mason; Balances, by F. A. Gould; Meters, by Edgar A. Griffiths; Calculating Machines, by Ellice M. Horsburgh; Comparators and Line Standards of Length, by W. H. Johnson; Combination of Observations, by H. L. Jolly; Mechanical Means of Integration, by Hyman Levy; Weighing Machines, by George A. Owen; Gauges, by Frederick H. Rolt; Clocks and Time-keeping, by Ralph A. Sampson; Metrology, by John E. Sears, Jr.; Humidity, by Sydney Skinner; Draughting Devices, by Alma Turner; Micrometers, by H. H. Turner; and Atmospheric Electricity, by C. T. R. Wilson. Ample cross-references and a good index are provided, and there are numerous references to other literature on many subjects.

Dimensional Analysis. By P. W. Bridgman. Yale University Press, New Haven, 1922. Cloth, 6 × 9 in., 112 pp., $5.

The substance of this book was given as a series of lectures to the Graduate Conference in Physics of Harvard University in 1920. The growing use of the methods of dimensional analysis in technical physics, as well as the importance of the method in theoretical physics, make it desirable that every physicist should have it at his command. Professor Bridgman's statement of principles is accompanied by many illustrations of their applications, especially chosen to emphasize the points concerning which there is the most common misunderstanding. Some of these deal with important questions of electrical theory, aeronautics, and other subjects of interest to engineers.

Drop Forging and Drop Stamping. By Henry Hayes. Isaac Pitman & Sons, New York and London, 1923. (Pitman's Technical Primers.) Cloth, 4 × 6 in., 108 pp., illus., $0.85.

In previous books on drop forging, attention has generally been concentrated upon a description of the plant used. A broader treatment has been attempted in this volume, particularly with a view to relating the mechanical with the metallurgical problems. The aim has been to provide an introduction to the equipment and methods of the drop-forge shop, to the principles underlying drop forging and to the heat treatment and hammer treatment of forgings. The question of dies is also discussed.

Electricity in Agriculture. By Arthur H. Allen. Isaac Pitman & Sons, London and New York, 1922. (Pitman's Technical Primers.) Cloth, 4 × 6 in., 117 pp., illus , tables, $0.85.

A small book indicating briefly the various ways in which electricity can be used by the farmer for light and power purposes and for electroculture, and the methods by which he can avail himself of electricity. The book also calls to the attention of central-station managers the possibilities of the farmer as a customer. Written for British farmers, it treats the questions in the light of British conditions.

Eléments de Mécanique, A L'Usage des Ingénieurs; Statique Cinématique. By Robert d'Adhémar. Gauthier-Villars et Cie, Paris, 1923. Paper, 6 × 10 in., 254 pp., 16 fr.

This textbook reproduces the course of instruction given by the author at the Institut Industriel du Nord de la France. It contains the elements of kinematics and dynamics, and an elementary development of statics.

Engineering Economics. By John C. L. Fish. Second edition. McGraw-Hill Book Co., New York and London, 1923. Cloth, 6 × 9 in., 311 pp., tables, $3.

This book treats of the principles which underlie economic judgment in the business side of engineering. The present edition, which is practically a new text, assumes choice of investment to

be the fundamental problem of engineering economics and proceeds to the analysis of this problem in a way that will give the student a working knowledge of the principles involved.

Engineering of Excavation. By George B. Massey. John Wiley & Sons, New York; Chapman & Hall, London, 1923. Cloth, 6 × 9 in., 376 pp., illus., diagrams, tables, $6.

The writer of this treatise, after spending practically all of his time since 1899 in the study of excavating problems and the application of machinery to them, has brought together the fruits of his experience. The book describes present methods of excavating and the machines and other equipment used in excavating and transporting both on land and under water. Capacities are given and the machines which are best suited for various kinds of work are indicated.

Gasmaschinen und Ölmaschinen. Vol. 1. By Alfred Kirschke. Vereinigung Wissenschaftlicher Verleger (Walter de Gruyter & Co.), Berlin and Leipzig. 1922. Boards, 4 × 6 in., 133 pp., illus., diagrams, $0.30.

This is the first of two small volumes, adapted to the pocket, in which are given a concise account of the origin and development of the internal-combustion engine. The present volume treats of small gas and oil engines. Chapters are devoted to gas as a source of power, early gas engines, cycles, general design and construction, valve gears, ignition and regulation, oil and spirit engines, automobile, airship and boat engines, gas producers, cost of operation, and gas and steam engines.

Hendricks' Commercial Register. 1923. S. E. Hendricks Co., Inc., New York, 1922. Cloth, 8 × 11 in., 2320 pp., $15.

Hendricks' Commercial Register endeavors to list all producers, manufacturers, dealers, and consumers connected with the engineering, chemical, metallurgical, railroad, contracting, and allied industries. It provides a ready directory to the manufacturers of an article and to the location of any firm. It also furnishes an index to trade names, enabling the manufacturer of any named article to be found. Over eighty thousand firms are listed in the 1923 edition.

Labor and Democracy. By William L. Huggins. Macmillan Co., New York, 1922. Cloth, 5 × 8 in., 213 pp., $1 25.

This volume, by the presiding judge of the Kansas Court of Industrial Relations, is a discussion of the relations between government and modern industrial conditions. The author endeavors to point out some of the dangers to democratic institutions inherent in the labor movement of today, to appraise the rights of labor, of capital, and of the public, to suggest legal principles upon which remedial legislation may be based, and to give the first results of the Kansas experiment in adjudicating industrial disputes.

Lehrbuch der Eisen- und Stahlgiesserei. By Bernhard Osann. Fifth edition. Wilhelm Engelmann, Leipzig, 1922. Cloth, 7 × 10 in., 693 pp., illus., diagrams, 24 mks.

This textbook of foundry is intended for beginners in the industry and also as a reference work for those engaged in iron and steel founding.

A concise but comprehensive account of the methods and appliances used is given, which is supplemented by numerous references to the literature and drawings. Special attention is given to molding methods, materials and machines. Chapters on steel and malleable castings are included. The volume concludes with a chapter on the metallography of cast iron.

Les Marées et leur Utilisation Industrielle. By E. Fichot. Gauthier-Villars et Cie., Paris, 1923. (Science et Civilisation.) Paper, 5 × 8 in., 254 pp., 9 fr.

The work of a chief hydrographic engineer of the French navy, this volume is a study of the possibility of using the energy of waves, on a large scale, as a source of industrial power. The author describes the action of the heavenly bodies on the waters of the ocean, the undulatory movements of the ocean, and the formation and propagation of waves. This study of the theory of waves is followed by an exposition of the projects intended to utilize the waves as a source of power. The book is intended not only for specialists, but also for legislators and others interested in economic problems.

Meaning of Relativity. By Albert Einstein. Princeton University Press, Princeton, 1923. Cloth, 5 × 7 in., 123 pp., $2.

This volume presents, in a translation by Prof. Edwin Plimpton Adams, four lectures delivered by Doctor Einstein at Princeton University, during May, 1921. The first lecture is upon space and time in pre-relativity physics; the second upon the theory of special relativity; and the remaining two upon the general theory of Relativity.

Machine Tools and Their Operation. By Fred H. Colvin and Frank A. Stanley. McGraw-Hill Book Co., New York and London, 1922. Cloth, 6 × 9 in., 2 vols., illus., diagrams, tables, $8.

This textbook is intended to give the mechanic an understanding of the principles involved in the operation of the ordinary machine tools, and thus enable him to adapt them to the various jobs that occur in the shop. Special attention is given to such subjects as cutting speed, clearance, angles, chip clearance, lubrication, speed and feed, and tool supports. The language is clear, simple and non-mathematical.

Metals and Their Alloys. By Charles Vickers. Henry Carey Baird & Co., New York, 1923. Cloth, 6 × 9 in., 767 pp., illus., tables, $7.50.

This work is based on Brannt's well-known work, Metallic Alloys, but the text has been so enlarged and so thoroughly revised that a new book has resulted. The book is intended to furnish modern, practical information on the composition and properties of industrial metals and their alloys, and on their manufacture, casting and working. The needs of the foundryman have been kept especially in view.

Modern Motor Car Practice. Edited by W. H. Berry. Henry Frowde & Hodder & Stoughton, London, 1921. (Oxford technical publications.) Cloth, 6 × 9 in., 582 pp., illus., $10.50.

This work, the result of the collaboration of a number of prominent English authorities on automobile engineering, is a valuable record of contemporary motor-car practice. An account is given of present methods of design and construction of each part of the automobile, with some review of the way in which present forms have developed, of the advantages and disadvantages of various designs, and of the trend of future change. Written in an interesting style and well illustrated, the book should prove of use to designers and manufacturers, and also to owners.

Practical Factory Administration. By Matthew Porosky. First edition. McGraw-Hill Book Co., New York and London, 1923. Cloth, 5 × 8 in., 244 pp., diagrams, $2.50.

The purpose of this book is to present the accepted principles of modern factory administration and to show how they may be effectively applied to actual operating conditions. It is addressed to executives, salesmen, cost accountants, and students of industrial administration. The principles, practices, and forms that it gives are presented from the point of view of the average rather than the exceptionally large establishment.

Principles of Electric Spark Ignition in Internal Combustion Engines. By J. D. Morgan. Crosby Lockwood & Son, London; D. Van Nostrand Co., New York, 1922. Cloth, 6 × 9 in., 94 pp., diagrams, $2.25.

In this little book an account is given of the scientific basis of electric spark ignition. During recent years much research has been undertaken on ignition problems, the main results of which, so far as they are of direct value to designers and students of gasoline engines, are here brought together. The design and constructional details of ignition apparatus have been excluded from this discussion.

Principle of Relativity with Applications to Physical Science. By A. N. Whitehead. University Press, Cambridge, 1922. Cloth, 6 × 9 in., 190 pp., 10s. 6d.

This book is not an attempt to expound Einstein's theory, but to set forth an alternative theory of relativity and to show the results deducible from the application of the formulas assumed for the gravitational and electromagnetic fields. Dr. Whitehead believes that our experience requires and exhibits a basis of uniformity, and that in the case of nature this basis exhibits itself as the uniformity of spatio-temporal relations; a conclusion that entirely

cuts away the casual heterogeneity of these relations which is the essential of Einstein's later theory. This uniformity is essential to the outlook of the author. He finally arrives at metrical formulas identical with those of Einstein's earlier theory, but with entirely different meanings ascribed to the algebraic symbols.

Problems in Machine Design. By O. A. Leutwiler. First edition. McGraw-Hill Book Co., New York and London, 1923. Cloth, 6 × 9 in., 133 pp., diagrams, tables, $1.50.

A series of isolated problems covering the various parts of the subject of machine design, intended to supplement those given in textbooks on that subject, and thus to give the student greater familiarity with the application of theory and a better working knowledge of the subject. Almost all the problems have been taken directly from existing machines, so that the student works with actual engineering information.

Seagoing and Other Concrete Ships. By N. K. Fougner. Henry Frowde and Hodder & Stoughton, London, 1922. (Oxford technical publications.) Cloth, 6 × 10 in., 216 pp., illus., diagrams, 10. $7.

The aim of the author is to present a true record of the principal seagoing concrete ships actually built up to the present, and to analyze the merits of these ships in comparison with ships built of wood and steel. The main part of this book is based on personal experience gained in the construction of about thirty vessels of concrete during the past five years. Information about ships built by others has been obtained partly through correspondence with the designers, builders or owners, and partly from the engineering press.

Standard Inventory Manual. By Frederic W. Kilduff. First edition. Accounting Standards Corporation, Chicago, 1922. Cloth, 6×9 in., 227 pp., charts, tables.

A reference book for managers of industrial enterprises, based on the practice of well known firms. Intended to assist him to prepare an inventory manual for his own firm which will contain complete, detailed rules for planning, preparing, taking, pricing and tabulating inventories with the least possible expense and loss of time.

Steam-Turbine Principles and Practice. By Terrell Croft. First edition. McGraw-Hill Book Co., New York and London, 1923. (Power Plant Series.) Cloth, 6 × 8 in., 347 pp., illus., $3.

Intended to provide the operating engineer and the plant superintendent with information required in every-day work. The topics treated are (1) those with which he must be familiar to insure the successful, economical operation of turbines, and (2) those which he must know in order to choose the proper turbines for any class of work. Design is not treated. The book is a clearly written account of steam turbines, written for the user, not for the designer or maker.

Structural Drafting and the Design of Details. By Carlton Thomas Bishop. Second edition. John Wiley & Sons, New York, 1922. Cloth 8 × 11 in., 352 pp., diagrams, tables. $5.

This book for students and structural draftsmen corresponds in scope to the duties of the structural steel draftsman, and therefore covers not only the preparation of the detailed workings drawing for steel structures, but also the design of the details of construction. It is a textbook in structural drafting and may be used as a textbook in elementary structural design. The new edition has been prepared to meet the extensive changes in the standards of the Association of American Steel Manufacturers. At the same time other changes and corrections have been made.

Tables Annuelles de Constantes et Données Numeriques de Chimie, de Physique et de Technologie. Vol. 4, 1913–1916. Two parts. Gauthier-Villars et Cie, Paris; Cambridge University Press, Cambridge, Eng.; University of Chicago Press, Chicago, 1922. Cloth, 9 × 11 in., 1377 pp., $13.57.

The annual tables of chemical, physical and technical constants and numerical data are prepared under the direction of the International Research Council and the International Union of Pure and Applied Chemistry, by an international committee. The aim of its editors is to summarize and present in convenient form for reference the data in its field which appear in the important periodicals and treatises of each year, and thus supply investigators with the latest results of research.

Volumes 1 to 3, issued in 1912, 1913 and 1914, covered the literature of 1910–1912. Volume 4, just published, covers that from 1913 to 1916 inclusive. Full references to sources of data are given.

Tool Engineering, Fixtures for Turning, Boring and Grinding. By Albert A. Dowd and F. W. Curtis. McGraw-Hill Book Co., New York and London, 1923. Cloth, 6 × 9 in., 340 pp., diagrams, $3.50.

The first volume of this series dealt with the design of jigs and fixtures. The present volume discusses the factors that affect the design of tools and fixtures for turning, boring, and grinding. Fundamental points in design are treated and the reasons why certain things are done are explained in detail.

Technische Schwingungslehre. By Wilhelm Hort. Second edition. Julius Springer, Berlin, 1922. Cloth, 5×8 in., 828 pp., illus., diagrams, $4.80.

The author has undertaken to collect and present in systematic fashion our knowledge concerning vibratory phenomena of technical importance. The book covers the mechanics of rigid, elastic, liquid and gaseous bodies and the field of electricity. Methods for investigating these phenomena are given, with examples taken from practice. An extensive bibliography is included.

Telephony. By Samuel G. McMeen and Kempster B. Miller. American Technical Society, Chicago, 1922. Fabrikoid, 6 × 9 in., 943 pp., illus., diagram, $5.50.

A descriptive, non-mathematical work covering the entire field of telephone engineering in one volume of reasonable size. Describes the customary types of subscribers' apparatus, line systems, switchboards, automatic systems, line construction, central offices, etc. Based on American practice.

Theory of Relativity and its Influence on Scientific Thought. By Arthur S. Eddington. Clarendon Press, Oxford, 1922. (Romanes Lecture, 1922.) Paper, 6×9 in., 32 pp., $0.70.

In this pamphlet containing the Romanes Lecture for 1922, Professor Eddington gives a clear, concise account, in non-mathematical terms, of the evolution of the theory of relativity.

Treatise on Weighing Machines. By George A. Owen. Charles Griffin & Co., London, 1922. Cloth, 6 × 9 in, 202 pp., illus., diagrams, charts. $3

This book, the first English treatise on its subject, explains in simple language the principles underlying the construction of weighing machines. It is intended as a guide to the proper types for various purposes and to methods of maintaining accuracy. The basic principles of all weighing machines are included in one or another of the types described.

20th Century Guide for Diesel Operators. By Julius Rosbloom and Orville R. Sawley. Western Technical Book Co., Seattle, 1922. Cloth, 6×9 in., 637 pp., portraits, illus., diagrams, $2.50.

The authors have attempted to furnish in compact form a summary of present-day knowledge of Diesel engines and their auxiliary machinery. The information given is presented in a form suited to the needs of those in charge of power plants and covers hath land and sea operation. Many commercial types of engines are described. One chapter is devoted to low compression or "semi-Diesel" engines.

Wechselstromerzeuger. By Franz Sallinger. Vereinigung Wissenschaftlicher Verleger. Walter de Gruyter & Co., Berlin and Leipzig, 1922. Boards, 4 × 6 in., 127 pp., diagrams, $0.25.

This booklet is intended, on the one hand, as an introduction to the subject of alternating-current generators, and on the other, to give engineers without special electrical training, who are connected with the construction or operation of these machines, an understanding of their essential characteristics. A special effort has therefore been made to explain these characteristics simply and to derive the most-used formulas and diagrams.

The windings are first explained, in connection with the generation and calculation of the electromotive force and the armature fields. After the vector diagrams have been derived, the experimental proving and the method of operation are treated. In conclusion data are given on the design, calculation and construction of alternators, with examples of actual machines which show how the formulas and diagrams are used.

Monel Metal Refinery and Rolling Mill

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is standard throughout, except that the housings are very heavy, weighing 12 tons each. The arrangement permits an addition of four mills on the other end of the motor drive. As there is very little fluctuation in the power required on this type of mill no flywheel has been furnished, but a motor with large starting torque is provided.

The Merchant Mills

It will be noted from Fig. 4 that in the building with the 24-in. merchant mill there are other merchant mills used for furnishing the greatly varied product in tonnages that, from a rolling-mill point of view, are small. This equipment consists of the 24-in. mill referred to previously, which not only makes sheet bar but also the various sizes of billets required, a 20-in. mill, a 14-in. mill, a 10-in. mill, and a 14-in. Belgian rougher; and the wire mill, which consists of two separate mills in line with each other, 9 in. pitch diameter, one being a five-stand roughing mill and the other a four-stand finishing mill. These mills are equipped with gears and direct motor drive and all have a flywheel on the motor-shaft speed except the 9-in. roughing mill, which due to construction difficulties has the flywheel on the mill-shaft speed. The 9-in. finishing mill drives direct without any flywheel or gear reduction.

All mills are driven by fixed-speed motors except the 10-in. mill, requiring a variation from 120 r.p.m. to about 80 r.p.m. to accommodate the varied size of material, and the 9-in. mill, the intermediate mill between the 14-in. roughing and 9-in. finishing mill, which will have a speed variation of 257 r.p.m. to 384 r.p.m., arranged in 17 intermediate steps, to accommodate the delivery speeds of the 14-in. mill.

The whole of the south side of this building is arranged with lifting doors, so that it is easy to adapt the temperature of this end to either summer or winter conditions, the same type of doors being arranged at intervals on the furnace lean-to side.

The dimensions and arrangements of the buildings are shown in Fig. 2. All of the buildings, with the exception of the office, laboratory, oil and grease house, and the electric substation, are of steel construction, the average weight per square foot of projected area being specified as 25 lb., although in some cases this is exceeded.

Wide monitors one-half the building width were adopted for the main building roof; the sawtooth roof was used for the lean-tos. These features give excellent ventilation and lighting. To assure the best working conditions during the warmer months, the prevailing winds were studied and the buildings placed accordingly.

Steel lifting doors are continuous on the sides of the refinery, hammer-shop, merchant-mill, and sheet-mill buildings. For truck or railroad entrances to buildings, rolling steel doors are provided.

The roofing and sheeting is of corrugated black sheets; the windows have wooden sash, which take up any variation in the steelwork and eliminate warping of frames which otherwise might occur. There is in all about 160,000 sq. ft. of these windows used in the entire plant. The buildings were given two coats of a non-corrosive paint and a finishing coat of battleship gray color, which gives a pleasing appearance and aids the inside lighting.

The Oil Venturi Meter

(Continued from page 298)

in the kinetic head and the friction loss the coefficient was computed and expressed by the formula—

$$C = 1/\sqrt{1 + (1.67/R)}$$

These coefficients were plotted on Fig. 1. This calibration applies equally well to any other size of venturi tube of the same shape. It shows that the coefficient decreases indefinitely as the slope of the lower part of the line becomes the constant 0.5. The general agreement with the experimental data for the glass model, which was of slightly different shape, shows that the assumption made in this computation was justified for low values of the turbulence but is not sufficient as the critical turbulence is approached. This is indicated by the dropping of the experimental line below the computed, and is probably due to the increased internal losses in the fluid with the higher readjustments of velocity in the cone. At low values of the turbulence the venturi tube acts merely as a resistance and is exactly as useful for the measurement of rate of flow as a piece of straight pipe with similar piezometer connections would be.

The data presented in Fig. 2 for the Simplex Standard venturi tubes are accurate to within 0.5 per cent for all values in the turbulent-flow region. This calibration is for all meters of 2:1 ratio of diameters for all sizes of tubes from 1 in. to 48 in. in diameter.

As liquids are usually transported at a much lower velocity (s) than the velocity (c) of sound in the liquid, the effect of the compressibility is negligible. The effect upon the venturi or pipe-line friction-loss coefficient due to the compressibility of the liquid flowing is found to be a function of s/c by the method of dimensions. When, as is frequently the case, gases and vapors are handled at the acoustic velocity (c) or higher, the coefficients must be considered as functions of s/c as well as of Qg/du. Experimental data compiled on a graph according to this method would provide a rational calibration of venturi, orifice, and pitot meters for use with steam and high-pressure gas or air. This same method might similarly be applied to show the performance of steam-turbine nozzles and jet pumps.

The thin-plate orifice and fixed pitot-tube meters may be calibrated by the use of this same method of dimensions. The fixed pitot tube is very sensitive to irregularities of flow in the viscous-flow region, especially with heated oils; however, experimental data are necessary to determine its value and range of usefulness.

The accuracy of measurements by the venturi or thin-plate orifice meters in the viscous-flow region may be considerably affected by heated oil or by valves and fittings near the venturi tube or orifice plate, especially when the fittings are located on the up-stream side. The amount of error due to these causes can only be determined by experiment.

The thin-plate orifice meter is less affected by the viscosity than the venturi meter at the lowest turbulences that are ordinarily used in practice; consequently the orifice is more suitable for use with fairly viscous liquids than is the venturi meter.

References

Model Experiments and the Forms of Empirical Equations, E. Buckingham, Trans. A.S.M.E., vol. 37(1915), p. 263.

Anomalous Results in Venturi Flume and Meter Tests, W. J. Walker, *Eng. News-Record*, May 11, 1922.

Effect of Viscosity on Orifice Flows, W. N. Bond, *Proc. Phys. Soc. of Lond.*, vol. 33, part 4, p. 225, June, 1922.

Computation of Coefficient of Discharge of Venturi Meters, W. S. Pardoe, *Eng. News-Rec.*, Sept. 25, 1919.

Measuring Flow of Fluids, J. M. Spitzglass, *Power*, Mar. 30, 1920.

Aluminum Bronze

(Continued from page 284)

shapes. This alloy can also be heat treated to some extent, in a manner similar to steel. By heating and quenching, its physical properties are improved to some extent, depending upon the exact composition of the material. It has been found that an addition of iron up to about 3 per cent in 8, 9, and 10 per cent aluminum bronzes improves their physical properties, workability, resistance to corrosion, etc.

The author's experience with a large variety of alloys from the manufacturing and the engineering viewpoint confirms his belief that the aluminum bronzes as a class are valuable additions to our list of engineering materials, and if he has pointed out some of the salient points, sufficient to arouse the interest of the engineer to investigate their merits further, the purpose of this paper will have been accomplished.

[In connection with the foregoing it is interesting to glance over Thomas D. West's paper on Casting Aluminum Bronze and Other Strong Metals in Vol. 8 (1887) of A.S.M.E. Transactions and one by Leonard Waldo on Aluminum Bronze Seamless Tubing in Vol. 18 (1897), both pioneer papers in presenting facts regarding this adaptable alloy.—Editor]

THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada)

Exigencies of publication make it necessary to put the main body of The Engineering Index (p. 117-EI of the advertising section) into type considerably in advance of the date of issue of "Mechanical Engineering." To bring this service more nearly up to date is the purpose of this supplementary page of items covering the more important articles appearing in journals received up to the third day prior to going to press.

AIRPLANE ENGINES

Navy Developments. Recent Developments in Aircraft Engines in the Navy, B. G. Leighton. Soc. Automotive Engrs.—Jl., vol. 12, no. 4, Apr. 1923, pp. 325–334, 12 figs. Former and present tests; progress made in development; reduction in weight; air-cooled vs. water-cooled engine; influence of power-plant weight on transportation costs.

AIRPLANE PROPELLERS

Reed One-Piece. Air Reactions to Objects Moving at Rates above the Velocity of Sound with Application to the Air Propeller, S. Albert Reed. Aerial Age, vol. 16, no. 4, Apr. 1923, pp. 182–185, 6 figs. Results of tests with Reed one-piece solid metal semi-flexible propeller.

AIRPLANES

Fokker. Fokker F5 Commercial Transport Airplane. Aviation, vol. 14, no. 14, Apr. 2, 1923, pp. 367–369, 4 figs. Convertible wing feature permits of speed and load variation for different services.

Wright All-Metal Pursuit. The Wright All-Metal Pursuit Airplane. Aviation, vol. 14, no. 14, Apr. 2, 1923, pp. 364–366, 2 figs. Duralumin cantilever monoplane characterized by excellent performance and military adaptability. Built by Dornier Co. in Switzerland, to fill American requirements.

AIRSHIPS

Goodyear Army TC1. Trials of New Goodyear Army Airship TC1. Aviation, vol. 14, no. 14, Apr. 2, 1923, p. 371, 1 fig. Novel features of non-rigid airship of 200,600 cu. ft. gas capacity; fitted with two 150-hp. Hispano-Suiza engines.

U. S. ZR3. Characteristics of U. S. Naval Airship ZR3. Aviation, vol. 14, no. 14, Apr. 2, 1923, p. 366, 1 fig. Capacity, 68,000 cu. m.; overall length, 206 m.; diam., 27.9 m.; max. breadth, 28 m.; max. height, 31 m.; power plant, five 400-hp.; max. speed, 79.3 mi. per hr.; cabin accommodations with sleeping quarters, 30 passengers.

AUTOMOBILE FUELS

Volatility. Motor-Transport Performance with Varied Fuel-Volatility, C. T. Coleman. Soc. Automotive Engrs.—Jl., vol. 12, no. 4, Apr. 1923, pp. 343–350, 9 figs. Data obtained regarding economic operation of motor vehicles with fuels of varied volatility, under service conditions.

AUTOMOBILES

Steering Systems. A Critical Study of Modern Automotive-Vehicle Steering-Systems, Herbert Chase Soc. Automotive Engrs.—Jl., vol. 12, no. 4, Apr. 1923, pp. 377–388 and (discussion) 388–397, 33 figs. Discussion of steering-gear faults.

BOILER PLANTS

Reconstruction. Rebuilding Boiler Plant Reduces Coal Consumption over One-Half. Power, vol. 57, no. 15, Apr. 10, 1923, pp. 546–552, 11 figs. Modern plant containing 6 water-tube boilers varying in size from 4000 to 5000 sq. ft. of heating surface, was built on site of old overload plant containing 15 boilers, without interruption to service.

BOILERS

A.S.M.E. Code. Comments on A.S.M.E. Revised Code for Testing Stationary Boilers, David Brownlie. Power, vol. 57, no. 15, Apr. 10, 1923, pp. 575–577, 1 fig. Criticism and suggestions for further revision, and necessity of international code.

CARBURETORS

Cadillac. Cadillac Makes Detail Changes in Carbureter Design. Automotive Industries, vol. 48, no. 13, Mar. 29, 1923, pp. 724–725, 1 fig. Double thermostat now used to govern relief of pressure on carburetor bowl; float valve redesigned.

CASE HARDENING

Method. New Method of Case Hardening, Frank Hodson. Forging & Heat Treating, vol. 9, no. 3, Mar. 1923, p. 160. Process introduced and patented by Assar Gronwall of Sweden consists of converting carbonic acid as formed to carbon monoxide.

CENTRAL STATIONS

Economic Operation. Effects 35 Per Cent Reduction in Generating Cost, D. E. Druen. Power, vol. 57, no. 13, Mar. 27, 1923, pp. 470–474, 5 figs. Changes in operating practices and building up of efficient personnel have resulted in average saving of $1000 per day in 50,000-kw. station of Kansas City Railways.

COST ACCOUNTING

Shop Office. Shop Office Accounting, Norman G. Meade. Indus. Management (N. Y.), vol. 65, no. 4, Apr. 1923, pp. 216–220, 14 figs. How three large corporations keep track of materials and stock.

COSTS

Graphic Analysis. Solving Cost and Economy Problems by Graphs, James A. Brown. Management Eng., vol. 4, no. 4, Apr. 1923, pp. 251–254, 3 figs. Management questions mathematically analyzed.

CUPOLAS

Charging System. Devise Flexible Charging System. Foundry, vol. 51, no. 7, Apr. 1, 1923, pp. 276–279, 7 figs. Describes layout adopted by Muncie Foundry & Machine Co., Ind., for handling materials from railway car to yard and from yard to cupola.

DIE CASTING

Methods. Die-Sinking Under a Drop-Hammer, Fred H. Colvin. Am. Mach., vol. 58, no. 12, Mar. 22, 1923, pp. 449–450, 4 figs. Method which saves time and money and helps to reduce cost of die castings; adaptation of silverware methods to another field.

ECONOMIZERS

Foster. New Foster Economizer. Power, vol. 57, no. 13, Mar. 27, 1923, pp. 485–486, 2 figs. Differs widely from those in general use, namely, in size of tubes used, placing them in horizontal position, use of cast-iron gilled rings on outside of steel tubes, and employment of water for cleaning tubes in place of scraper or steam blowers.

ELECTRIC WELDING, ARC

Cyc-Arc. A Development of the Cyc-Arc Welding Process. Engineer, vol. 135, no. 3508, Mar. 23, 1923, pp. 306–309, 9 figs. With present machine it is said to be possible not only to weld dissimilar metals and alloys together, but also identical metals.

Flash. Flash Welding, A. L. De Leeuw. Am. Mach., vol. 58, no. 12, Mar. 22, 1923, pp. 433–436, 5 figs. Advantages over slow butt welding; current consumption and pressures required; limitations; welding non-ferrous metals.

EMPLOYEES

Rating Scales. Are Rating Scales Justified? Eugene J. Benge. Indus. Management (N. Y.), vol. 65, no. 4, Apr. 1923, pp. 199–202, 4 figs. Results of investigation conducted by author on group of 51 men in attempt to analyze criticisms of rating-scale validity.

FORGE SHOPS

Germany. Famous German Forging and Machine Plant, Godfrey L. Garden. Iron Age, vol. 111, no. 13, Mar. 29, 1923, pp. 886–887, 3 figs. Describes plant of Haniel & Lueg at Düsseldorf for manufacture of steam-hydraulic presses, blowing and gas engines, pumps and rolling mills.

FORGING

Hydraulic Presses. Observations on the Construction and Installation of Hydraulic Forging Presses, W. R. Ward. Forging & Heat Treating, vol. 9, no. 3, Mar. 1923, pp. 143–146. Outline of manufacture of forging presses; various operations and materials; foundations; installation and testing.

FOUNDRIES

Labor-Saving Machinery. Eliminating Skilled Foundry Labor, F. L. Prentiss. Iron Age, vol. 111, no. 14, Apr. 5, 1923, pp. 949–954, 10 figs. Special machines and conveyors result in producing 500 Chevrolet 4-cylinder castings per day with only 17 semi-skilled men and 28 flasks.

GAGES

Measuring Machine. The Wickman Gauge Measuring Machine. Engineer, vol. 135, no. 3506, Mar. 9, 1923, pp. 266–268, 8 figs. Machine for verification of workshop gages, to be carried out quickly and accurately.

GEARS

Burnishing. Burnishing the Teeth of Gears, Ellsworth Sheldon. Am. Mach., vol. 58, no. 9, Mar. 1, 1923, pp. 325–326, 1 fig. Corrects minor errors of contour, smooths and densifies tooth surface; analogous to cold hammering; forestalls effects of distortion in hardening.

INDUSTRIAL MANAGEMENT

Methods and Principles. Management Methods and Principles of Frank B. Gilbreth, Inc., K. H. Condit. Am. Mach., vol. 58, nos. 1, 8 and 12, Jan. 4, Feb. 22 and Mar. 22, 1923, pp. 33–35, 293–295 and 443–447, 14 figs. Jan. 4: Principles of application of psychology to management. Feb. 22: Plant survey; use of stereoscopic camera; collecting blank forms, written orders and blueprints; disposition of useless material; process charts. Mar. 22: Principles upon which process chart is constructed and tools used; functions of organization chart; route models and their use.

Statistics of Industry. Signals for Business Conditions, Ernest F. DuBrul. Management Eng., vol. 4, no. 4, Apr. 1923, pp. 259–264, 5 figs. Statistical flags of industry show what to do and when to do it. Points out that study of industry's statistics of orders and prices enables one to lay out proper division of its cycle into various sectors.

LOCOMOTIVES

Exhaust-Steam Utilization. Condensing and Utilisation of Exhaust Steam in Locomotives. Engineer, vol. 135, nos. 3507 and 3508, Mar. 16 and 23, 1923, pp. 279–281 and 303–304, 7 figs. Consideration under two heads: (1) locomotives which condense comparatively small volume of exhaust, generally for purpose of feedwater heating; (2) locomotives which condense whole of exhaust in order to expand steam down to lowest pratical possible pressure below that of atmosphere.

MOLDING METHODS

Green-Sand Cores. Foundryman Develops New Practice, H. E. Diller. Foundry, vol. 51, no. 7, 1923, pp. 252–256, 9 figs. Describes method developed by Edwin Jory of handling green-sand cores in mold. Molding operations and devices in gray iron and steel shop.

OFFICE MANAGEMENT

Routine Charts. The Use of Routine Charts, G. Charter Harrison. Management Eng., vol. 4, no. 4, Apr. 1923, pp. 223–228, 2 figs. Improving and systematizing office procedure. Author shows by example how to analyze procedure by arranging various forms on chart.

RAILWAY SHOPS

Production Methods. Production Methods in a Railroad Shop, L. S. Love. Iron Age, vol. 111, no. 13, Mar. 29, 1923, pp. 881–885, 25 figs. Improvements in fixtures and tools effect savings in cost of work; parts machined in multiple fixtures; waste material reduced.

Scrap Reclamation. Railroad Salvage and Other Shop Work, S. Ashton Hand. Am. Mach., vol. 58, no. 13, Mar. 29, 1923, pp. 469–472, 14 figs. Reclamation of materials; substitute for turntable; milling teeth in spherical cutter. Practice at Emerson Shops of Atlantic Coast Line R. R., South Rocky Mount, N. C.

STEAM-ELECTRIC PLANTS

Oil-Burning. High Efficiency Oil-Burning Station, C. H. Delany. Elec. World, vol. 81, no. 13, Mar. 31, 1923, pp. 735–738, 7 figs. Installation of 12,500-kw. horizontal turbine, operating at 1800 r.p.m. directly connected to 3-phase, 60-cycle, 12,000-volt generator; boilers are provided with steam-atomizing oil burners; use of graphic meters.

STEEL MANUFACTURE

Electric-Furnace. Electrically Melted Ferro-Manganese Improves Converter and Open Hearth Practice, Frank Hodson. Blast Furnace & Steel Plant, vol. 11, no. 4, Apr. 1923, p. 243, 1 fig. Points out with proper metallurgical manipulation of ferromanganese, it is desirable to use electric furnace with large open bath rather than restricted channel.

Figuring Alloys. Short Method for Figuring Alloys, J. M. Quinn. Blast Furnace & Steel Plant, vol. 11, no. 4, Apr. 1923, pp. 232–238. Comprehensive system of tables and proportions used by practical steel makers.

STOKERS

Low-Grade Fuel. Stokes Anthracite Culm and Gashouse Tar, Joseph Harrington. Power, vol. 57, no. 14, Apr. 3, 1923, pp. 523–524, 3 figs. Mixture of anthracite dust and liquid tar from gas producers is burned successfully on forced-draft chain-grate stokers with no modification of furnaces at plant of Consolidated Gas & Elec. Co., Long Branch, N. J.

Pluto. The Pluto Mechanical Stoker. Engineering, vol. 115, no. 2985, Mar. 16, 1923, pp. 325–328, 25 figs. Arrangement and details of stokers developed by N. V. Maatschappig Pluto, of Nijmegen, Holland, which are in successful use in large power station at Amsterdam and elsewhere on Continent.

WAGES

Merit System. A Merit System for Establishing Wage Rates, K. H. Crumbine. Am. Mach., vol. 58, no. 8, Feb. 22, 1923, pp. 301–302. Describes universal plan based only on merit, claimed to be just to all employees.

WATER POWER

New York. Availability and Economics of Hydro-Electric Power for New York. Power, vol. 57, no. 14, Apr. 3, 1923, pp. 508–514. Abstracts of following papers: Coördinated Statement of Problem, F. W. Scheidenhelm; Available Water Power and Cost of Delivery, W. S. Murray; Requirements of Service for Hydro-Electric Power, George A. Orrok; Factors Affecting Quality of Hydro-Electric Service, F. A. Allner; Reliability of Long-Distance Transmission, Lorin E. Imlay. Discussion.

New York State's Water Power, Guy E. Tripp. Elec. World, vol. 81, no. 12, Mar. 24, 1923, pp. 685–686, 1 fig. Reasons why it must not be isolated or developed individually; advantages of interstate transmission and superpower systems which embrace steam-driven as well as water-power stations.

WOODWORKING MACHINES

Planing and Molding. High-Speed Wood Planing and Moulding Machines. Engineering, vol. 115, no. 2986, Mar. 23, 1923, pp. 365–366, 6 figs. partly on supp. plate. One machine is capable of producing tongued-and-grooved flooring and matchboarding at speed of 250 ft. per min., and other of shaping boards to various moldings at 80 ft. per min.